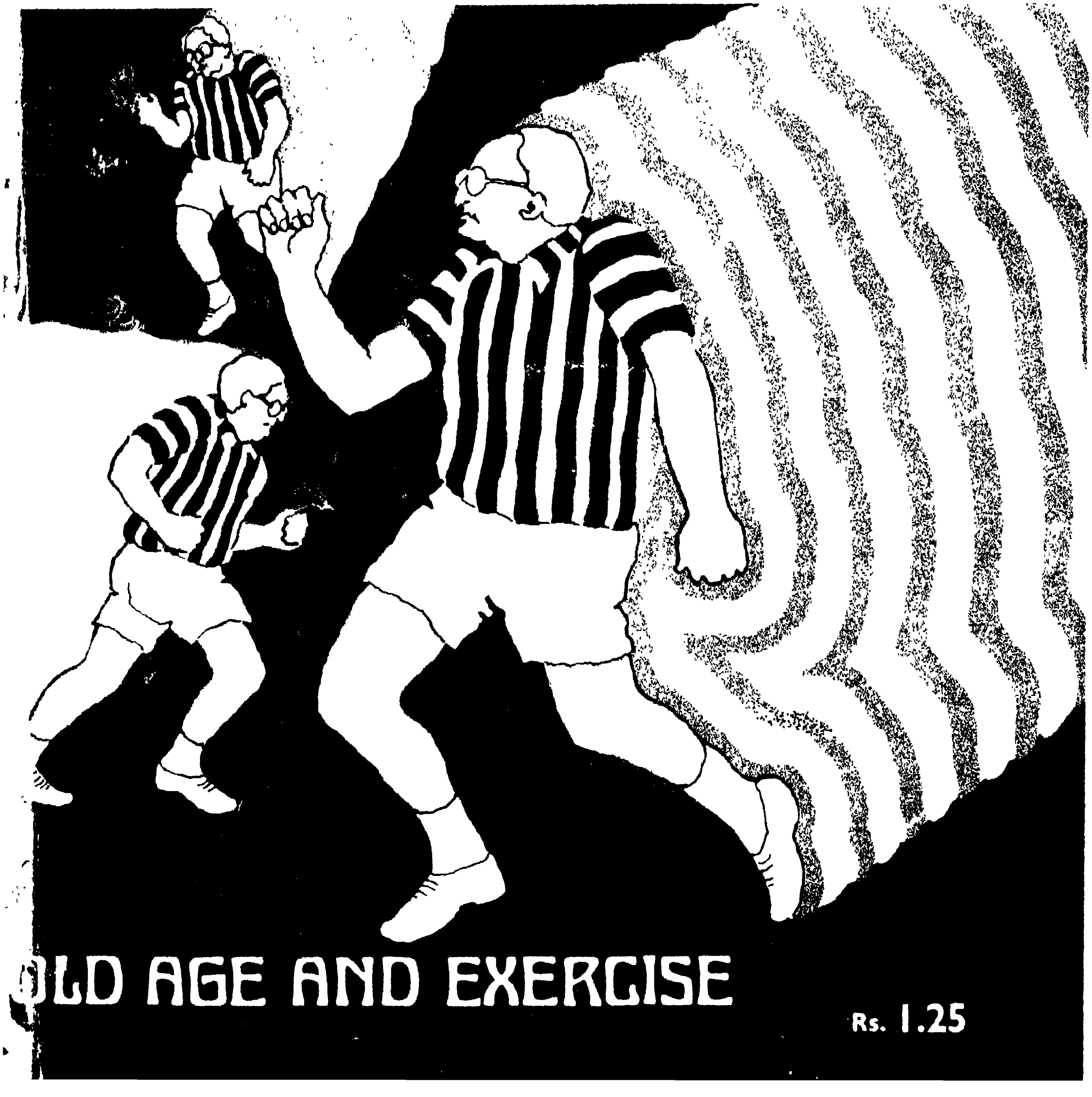
A TIMES OF INDIA PUBLICATION

OCTOBER 1973

SCIENCE TODAY

FOR EVERYMAN



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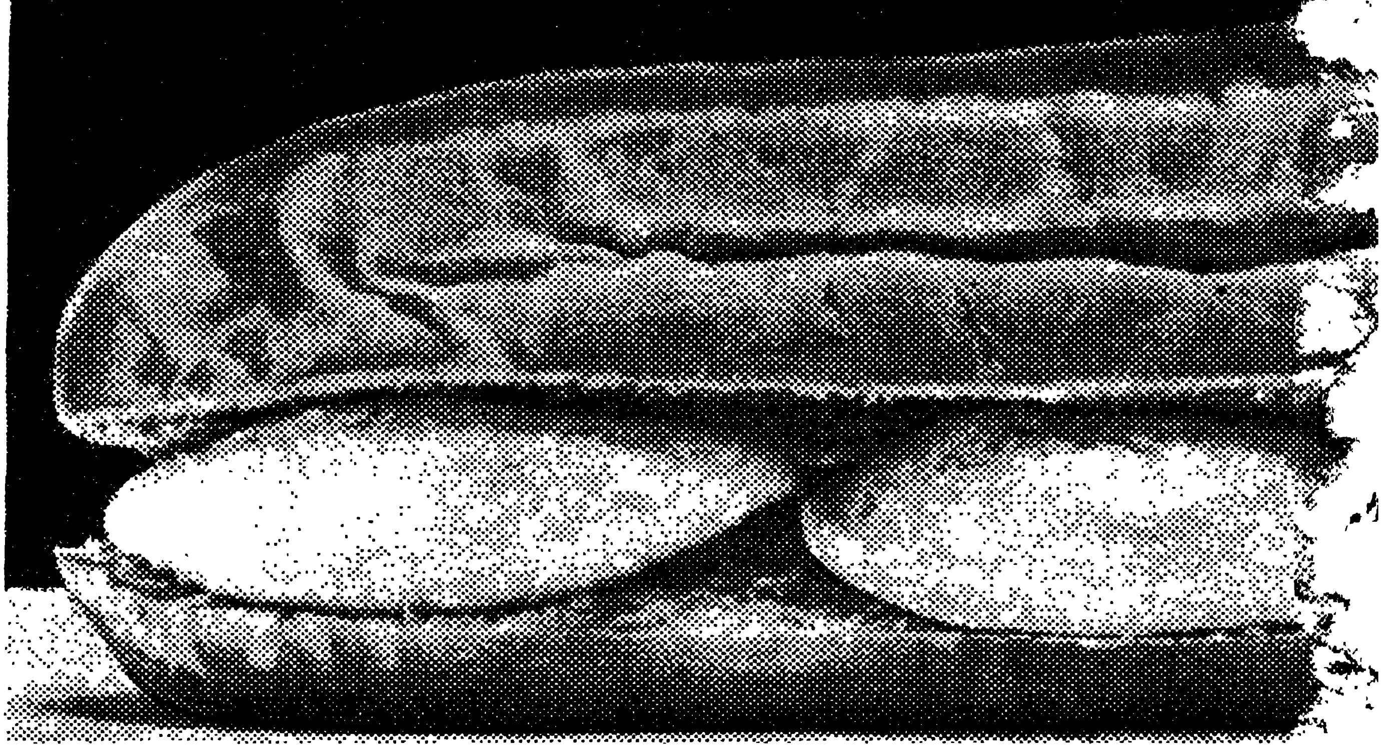

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Science Today October 1973

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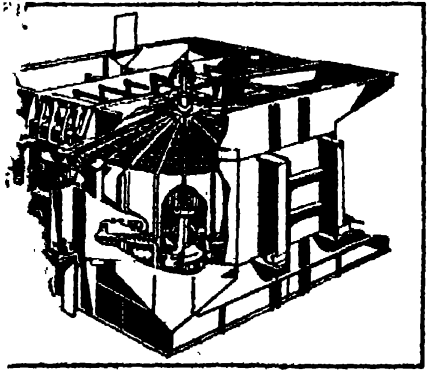

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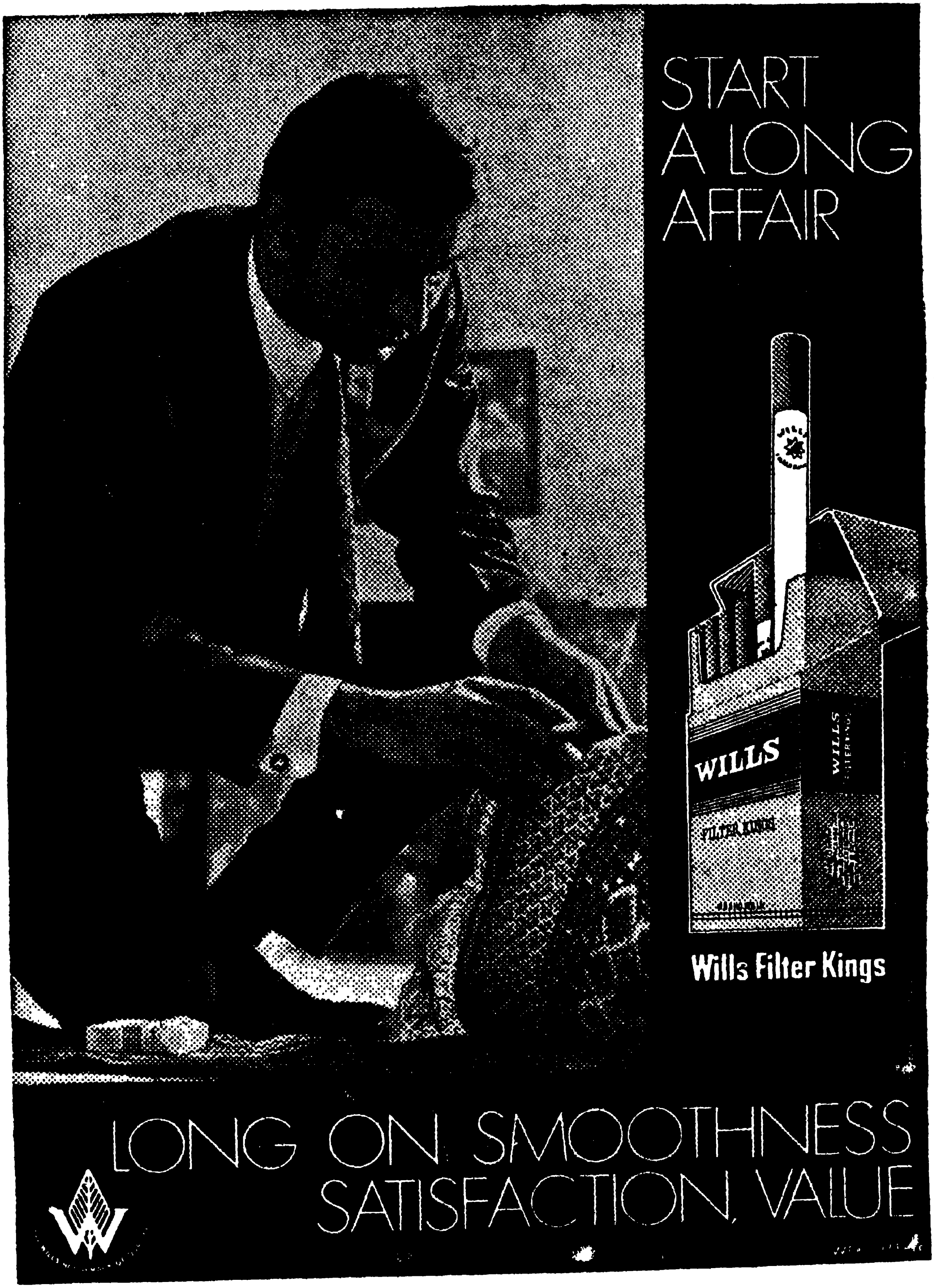
START A LONG AFFAIR
WILLS
FILTER KINGS
WILLS
Wills Filter Kings
LONG ON SMOOTHNESS
SATISFACTION, VALUE

SCIENCE TODAY

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WHICH ONE IS THE TAJ ? p. 43

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15 TOTAL ENERGY CONCEPT FOR MORE POWER

Durgesh Chandra & P. R. Srinivasan

The immediate solution to our nagging power crisis may lie in the fuller utilisation of fuels through the total energy concept

30 OLD AGE & EXERCISE

At which year of life do the mind and the body begin to age? Can exercise bring on rejuvenation as an American study has shown? These questions are discussed in four parts

- **HOW AGE AFFECTS THE BODY & THE MIND**
  M. S. Malhotra
- **THE MIND OF THE BODY-FIT**
  R. L. Anand & D. N. Mathur
- **I AM OVER FORTY. SO WHAT?**
- **IN SEARCH OF THE ELIXIR**

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M. C. Joshi

Behind the architecture of this marvel in white lies centuries of tradition of Mughal and pre-Mughal design concepts. Yet the Taj has a lot that is unique

49 BLOOD WILL TELL

S. Sivaram

Blood drops at the scene of crime or on a suspect's person can help prove his guilt, or innocence. The forensic biologist can identify over 90 different blood types

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COVER
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Shabbir Diwan

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EDITOR
SURENDR JHA

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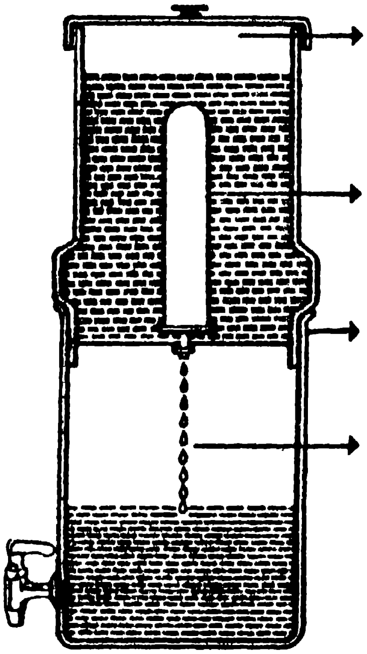

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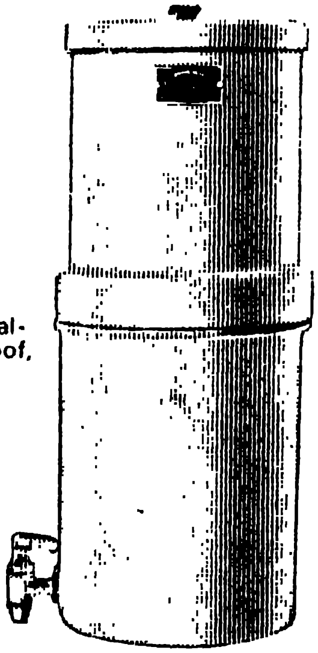

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letters

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Photomorphology of Gulmohurs

THE Homi Bhabha Road leading to the Tata Institute of Fundamental Research at the southern tip of Bombay is an avenue of trees with a row of gulmohurs decorating its northern wing and a part of the southern wing. Alternating with the gulmohurs are the street lamps. And these lamps have a curious photogenetic effect on the growth and flowering of these trees.

Normally, gulmohur or *Delonis rogia* sheds its leaves by the end of the year. New leaves appear in March followed by flowering, rather uniformly all over, by the second half of April. However, under the effect of the prolonged exposure to street light, the illuminated area has an early intense growth of leaves, and late and sparse flowering, whereas the other side of the tree, away from light, has an early and extensive flowering and hardly any leaves even after a month of flower initiation. In early May, every tree next to a street lamp gives a half-green-half-red appearance because of this photomorphological effect.

Light is known to be one of the most powerful agents affecting plant growth. Synthesis of sugars by chlorophyll (photosynthesis), bending of plant organs towards light (phototropism), their oriented movement such as in sunflowers (phototaxis) and changes in biological rhythms as governed by light-cycles (photoperiodism) are some of the more familiar phenomena.

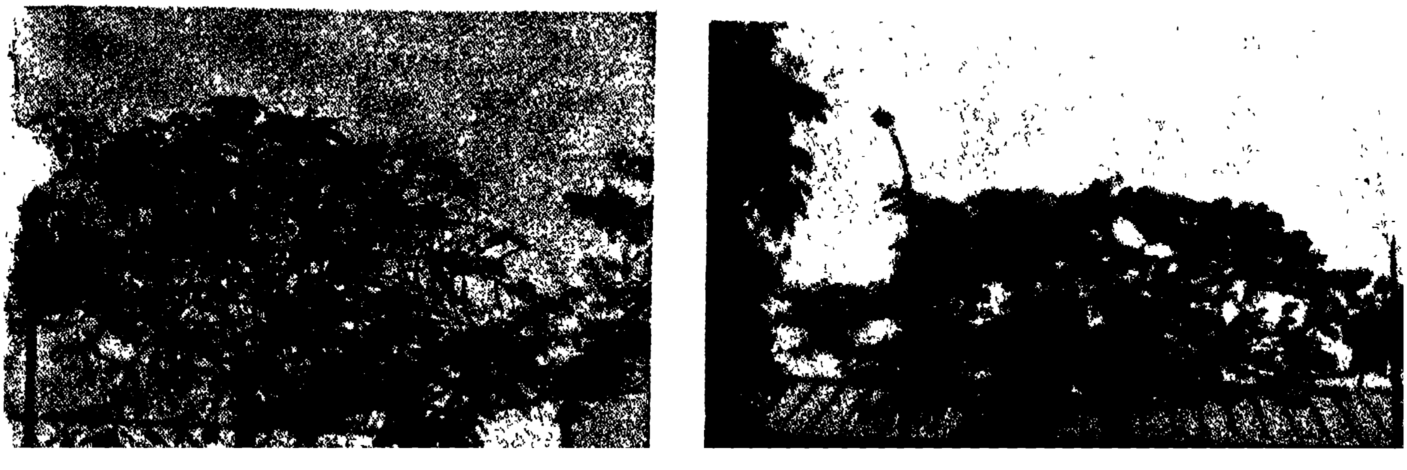
The morphological changes seen here are probably due to photoperiodism, ie the cycle of light and dark periods which affect the budding and flowering of plants. It is known that a short-day plant will flower only if it has received a certain number of short days (say, 8 hr light/day), but will not flower if kept under long day conditions (say, 16 hr light/day). For a long-day plant the reverse is true, that is, if it is kept under short period light conditions, it will not flower. There is a pigment, phytochrome, which is sensitive to light and when irradiated goes into various shades of red, far-red or blue light which in turn control such processes as synthesis of proteins and polypeptides. The transformation of phytochrome from red (P_r) to far-red (P_{fr}) state is used by a plant to determine if there is light or darkness, and certain biochemical reactions are promoted or inhibited depending on the concentration of various states of this pigment. Also, the plants have their own physiological clocks, independent of external environmental conditions. These endogeneous rhythms together with the presence or absence of P_{fr} (which is also formed under white light) promote or inhibit the flowering or budding of trees. Synthesis of P_r as well as quick disappearance of P_{fr} in darkness through decay or conversion are essential for controlling the function of phytochrome in photoperiodism. This or another light-sensitive pigment is probably responsible for the differential photomorphogenesis of gulmohurs.

Phototropism — bending of the tree towards light — can also be noticed in the case of young trees but this probably is an effect caused by differential gravitational forces due to a copious growth of leaves on the irradiated side. Such samples are frequently found, a dramatic case being that of a gulmohur at the Electric House junction on Wodehouse Road of South Bombay. Naturally lighted trees are usually upright and straight.

Watching these trees day by day till the onset of summer, one can't help a wild thought: the flowering is so extensive (and leaves almost absent on the farthest side of a lamp) that would it be possible by some trick to grow an all-flower tree?

Dr. N. Bhandari

Geophysics Group, TIFR, Bombay



Left: A normal tree without a near-by street light. Right: A tree with a street light next to it shows photogenesis — the left half of the tree is green with leaves while the right half is red with flowers. (Both trees are on the Homi Bhabha Road in South Bombay.)

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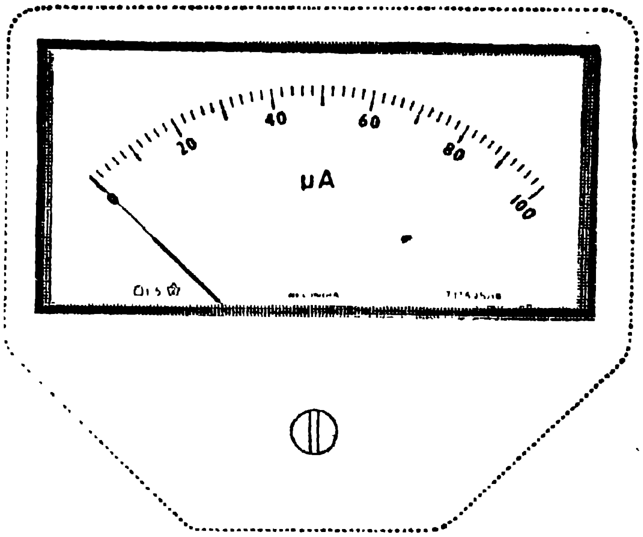

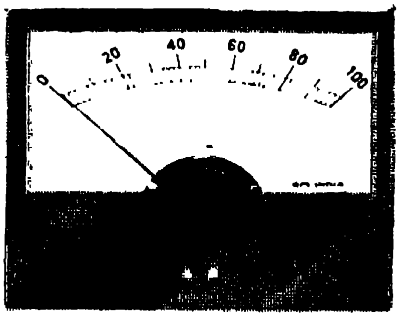

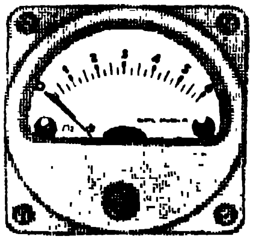

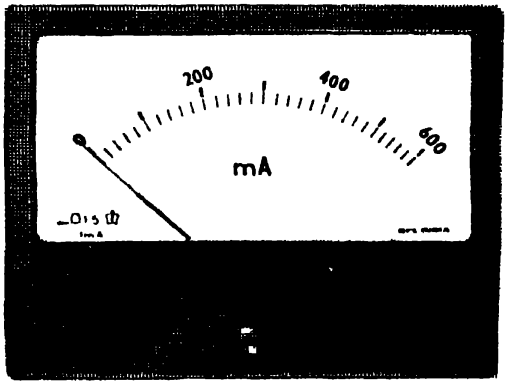

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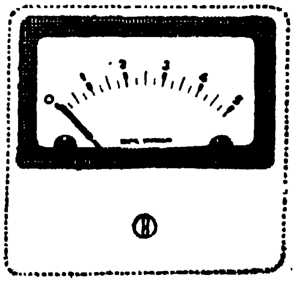

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letters

"Is the Indian scientist well-paid?"

Mr. Kamalesh Ray says (Science Today, July 1973) the point rating system of job evaluation is too elaborate to be of any use in India as job factors and point values are, by no means, easy to fix with accuracy. I want to inform him that the point rating system is well under practice in the Rourkela Steel Plant for the last so many years for determining the pay scales and promotion of non-executives and executives and has been found to be quite satisfactory. Here 13 factors for point rating are considered for job evaluation.

R. K. P. Singh
Rourkela Steel Plant

"ESP—the other reality"

Mr. S. K. Ghaswala says ("Letters", Science Today, August 1973) Shri Sathya Sai Baba can materialise things. It would be really helpful to the nation if he can meterialise grains, eatables and drinking water for our starving millions. If Baba limits his powers to produce only flowers and vibhuti, it is not a wise act for a so-called godly man to perform.

Suresh Kumar
Bombay Rationalist Association

Power from fusion

"Power from Fusion" (July 1973) by Prof. Sudhanshu S. Jha was quite informative. To obtain power from fusion is indeed one of the most challenging problems that scientists face today.

Prof. Jha points out that compressions can be very effective in reducing the energy requirements to initiate fusion, from about 10^8–10^9J to 10^5–10^6J. Following an ingenious suggestion from Dr. Edward Teller, it has been proposed to compress the pellet by means of a rapidly converging shockwave, generated by irradiation with six laser beams. The idea will become clear, if we look at the formula for energy required:

$$E = 10^7 \left(\frac{n_0}{n}\right)^2 \text{J},$$

where n_0 is the initial density and n is the final compressed density. So if we achieve compression by a factor of 10, the required energy goes down to 10^5J.

Besides the lasers, another scheme to bring about thermonuclear fusion has been proposed. It is to use high intensity, relativistic electron beams, produced by field emission. The problem becomes more complicated by the presence of plasma. Also, focusing such a high intensity beam is a difficult task. But it is reported that if the beam is focused well, relativistic electron beam can be more efficient than lasers.

S. A. Antani
Bhabha Atomic Research Centre, Bombay

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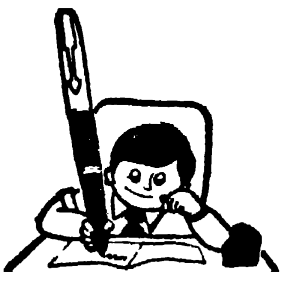
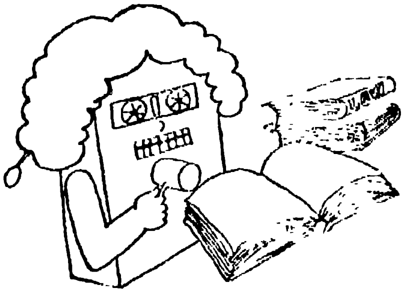


Vision 711

science shapes life

Computers aid Watergate investigators



"The President knew about it!" "No he was ignorant about it!" "But this proves it!" "Its cooked up!" The critics accuse. Ex-party members decry. There are many charges and almost as many different versions of the episodes as there are witnesses and counter-witnesses.

The investigators are now using computers to correlate the information supplied by different people on the same subject. Three different investigations — the Watergate burglary, political espionage and campaign finances — will be computer-examined. Senator Sam J. Ervin's Special Committee is using a huge computer to investigate the presidential campaign activities. The data is being fed to the computer by law students of the Georgetown University, USA.

When do the dead really die?

How do you determine death? When respiration stops? When the heart stops beating? When the electroencephalogram of the brain shows a "flat"? The dividing line between life and death may not be as fine as it was thought to be. The crossing takes at least an hour and a half, says Professor Klaus Zulch, Director of the Max Planck Institute for Brain Research, Cologne, West Germany. His conclusion is based on research done by a young Cologne physician, Dr. Hossmann.

Working with cats and dogs, Dr. Hossmann found that "dying in certain cases, in which the heart has stopped pumping blood, can be reversed". Till now it was believed that the brain died soon after the blood supply was cut. The maximum time during which the central nervous system survived without blood was placed at 20 minutes. And even this was called an overestimation.

Dr. Hossmann found that stoppage of blood to the brain led to a shrinkage of blood vessels leading to and from the heart. Even when the circulation was restored, the vessels remained contracted. But they could be dilated by increasing the blood pressure. Dr. Hossmann cut off the blood supply to brains of the laboratory animals for at least an hour, and then restored it by raising the blood pressure. In about two-thirds of the animals, the blood cells were undamaged. Within three hours the recovery was complete.

Too much information!

It is going to be "information pollution" now, says Georges Anderla, a French economist. Scientific and technical information is growing exponentially by 12 to 30 per cent every year. It may go up to 30 or 40 per cent with the introduction of data-handling systems.

Anderla's conclusion is based on his two-year study conducted at the request of the International Organisation for Economic Co-operation and Development. Over ten million authors contribute to the glut of information, says Anderla, and they are producing more than any previous estimate.

Of cats and cancer

It's bad news for cats. New York City and Boston (both in USA) scientists report that cat leukaemia is contagious.

The team headed by W. O. Hardy Jr. of the Sloan Kettering Cancer Center in New York City, USA, found that transmission of cat leukaemia virus was common in domestic cats. And infected cats could develop the disease.

The virus was identified in 1964, and it was found in 90 per cent of leukaemic cats. The same virus was also linked with several other diseases including some anaemias.

Hardy's team undertook to study if viruses could be transmitted to healthy cats by diseased animals, and if the new hosts developed the disease. Of 543 cats living in households with at least one leukaemic cat, one-third were infected. About 23·7 per cent of these developed leukaemia or anaemia. The time-lag between the detection of the virus and development of the disease was 5·3 months.

Grooming and sharing common kitty litter are said to transmit the virus. The virus was found in the salivary glands of 32 of the leukaemic cats. Antigens were found in the kidneys of 70 per cent of the diseased animals.

How susceptible is man to the cat cancer? Hardy found that 130 people in close contact with infected cats had *not* harboured the virus. The virus has not been associated with any human disease yet. Human tissue can be used to cultivate the virus, though.

The French economist who delivered his paper at a meeting of information specialists in Washington, USA, urged governments to evolve efficient methods of screening information for preservation and assuring its free flow to the public.

And now, alcoholic leftists

Are left-handed people more prone to alcoholism? Paul Bakan of Simon Fraser University, USA, thinks so. He found that in a group of 47 hospitalised alcoholics, the proportion of left-handers and ambidextrous persons was three times the normal proportion in the US population.

It has been found that left-handedness and two-handedness are more common among people suffering from certain neuropathological syndromes such as cerebral palsy, epilepsy, mental retardation and language problems. These conditions and left-handedness are related to complications during and before birth. Therefore, Bakan concludes, brain pathology due to oxygen starvation during or before birth could lead to the development of alcoholism.

Glass casts for broken bones

The bulky, heavy and old-fashioned plaster of Paris moulds may soon be outdated by glass fibre. The new material, fibre-glass web, will make casts three times as strong and about half as heavy as the plaster casts.

To form the glass cast, the affected limb is first covered by propylene stokinet and propylene web. This cushions the limb against the solid cast. Next, the glass web treated with a photo-sensitive resin is wrapped around to conform with the shape of the limb. This done, the cast is exposed to ultraviolet rays for about three minutes. It sets.

This glass protection for fractured bones has been developed by a Pennsylvania (USA) firm. It makes it easier to wear clothes, and with the doctor's permission, you could even swim!

Injecting life into foetuses

Sometimes, babies get strangled to death during the process of birth. Treating foetuses in the womb is a challenging problem for perinatal researchers. Now scientists in Basel, Switzerland, have been successful in treating them as they are being born.

T. H. Lipper and P. M. Roemer injected glucose bicarbonate into scalps of healthy foetuses. The half-hour-long injection increased the glucose level in the blood. This method may help restore asphyxiated babies.

In animal experiments, glucose and carbonate injections have increased the survival time of artificially asphyxiated foetuses.

Puff up ulcers

The little white magic-wand that reduces stress and calms the nerves has one more hazard tagged on to it. In addition to being linked with cancer, heart disease and lowered resistance to disease, cigarettes are said to cause ulcers too. How? N. W. Read and P. Grech of the Northern Hospital, Sheffield, UK, seem to have an answer.

Using 22 volunteers — nine of them were dyspeptic, others normal — they studied the effects of cigarette smoke on the pyloric sphincter (it prevents food from being pushed back into the stomach from the intestine). The stomach secretes an acid so powerful that it can destroy its own walls. However, this is prevented by a protective layer.

When a person smokes, the scientists discovered, the pyloric sphincter loses its competence. There is a back-flow of the food into the stomach. The bile in it destroys the protective layers and the acid gets access to the stomach walls. Ulcers are formed.

Smoking just before a meal is more harmful, according to the scientists. The stomach usually secretes acid in anticipation of food just before meal-time. Smoking at such a time will let the concentrated acid attack the walls. Food dilutes the acid to a certain extent. (A little leakage is normal and it is generally of no consequence.)

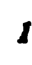
Using radio-opaque food, the scientists studied the effects of cigarettes on the pyloric valve by means of X-rays. Within minutes of smoking, the pyloric muscle lost its tone. They attribute this reaction to nicotine, or as a reflex action to the irritation of the air passages.

Absorbent roads

Soon Americans will walk or drive on absorbent asphalt-coated roads that would prevent flooding and obliterate the need of roadside drains. The water-absorbing asphalt has been developed at the Franklin Research Labs, USA. Apart from preventing flooding, the asphalt will reduce streambed erosion which causes storm water pollution. It will allow plant life to thrive amidst it and also reduce wet skidding. Also, it will provide a useful way to discard urban debris -- the debris can be used instead of gravel to fill the reservoir layer. (See figure.)

The town of Woodlands near Houston, Texas, USA, will be the first place to have absorbent roads.

What if the pores of the road get clogged? Vacuum-clean it.



For clear vision

Condensed water vapour on windshields is a recurring nuisance to drivers in cold climates. Every few minutes it has to be wiped off thus distracting the driver. Cigarette tobacco, plain saliva, etc are some of the unsuccessful *home remedies*.

The Defence Research Laboratory (Materials), Kanpur, has developed an antimisting formula comprising of a non-ionic detergent, fused calcium chloride, magnesium chloride, sodium silicate, sodium hydrogen phosphate, sucrose and glycerine. The components melt the ice and maintain the power point as low as possible, and keep its viscosity within working range.

Ten grams of the antimist soaked in muslin and enclosed in a polythene bag will cost about 35 paise.

Carbohydrate affects growth

Opaque-2-mutant is a new corn strain containing all the essential amino acids. Children suffering from kwashiorkor, a protein deficiency disease, have been cured by it.

The corn has a high level of carbohydrate. And studies at Boston City Hospital, USA, show that an exclusive diet of the corn reduces growth hormone secretion in adults. The investigators relate this to its high carbohydrate content. Diets with lower carbohydrate and equal or even less calories did not produce such side-effects. Whether children are similarly affected is not known.

From stench to fragrance

Factories, garbage dumps, open sewers, etc are sources of olfactory annoyance. Imagine living near a chemical factory; the wind carries in the stench and there is no alternative but to shift to a new place.

Malodour is a less understood form of pollution which cannot even be quantified. A particular odour may be pleasant when diluted or mixed with another odour but repulsive when isolated and concentrated. Two malodours may combine to give a pleasant smell, less intense than either of the two components!

Oscar B. Lauren describes the modification methods in *Pollution Engineering*. Various combinations of smells are tested by professional sniffers. And a suitable 'modifier gas' to match the requirement is selected. The modifier gas reduces the nuisance value of the effluent gas when mixed with it. However, there is one danger: the modifier can be abused to mask toxic gases too.

Fixing the green revolution

High yielding grains, bumper crops! Now what's the matter? These high yielding crops are draining the soil nutrients. Expensive nitrogenous fertilisers — the only answer at present — will not solve the problem forever. If only these high-yielding plants did not have to be spoon-fed! The scientists are trying to figure that out.

Leguminous plants harbour certain useful bacteria, like rhizobium, to obtain nitrogen (N) directly from the air. Work is being done to introduce this bacterium into the cereal-plant roots.

Professor Edward Cocking, M. R. Davey and Eileen Bush of the University of Nottingham, UK, have isolated rhizobium-infected root cells of the soyabean. These will be fused with root cells of other plants to cross the N-fixing property into the new host. The improved cells will then be implanted back to the parent plants.

Another method is to introduce the nitrogen-fixing gene into the plant cell. Meanwhile, there is exciting news from the CSIRO in Australia. Dr. M. J. Trimick has discovered a rhizobium that attacks non-cereal plants. The idea is to infect cereal plants with this microbe.

TV makes a dull child?

Your child can sit on the living room chair and catch glimpses of every corner of the world. His general knowledge may increase, but strangely his creativity slumps. Stanely Stern of the USC School of Education, USA, studied 250 intelligent children's reaction to TV-watching. He divided them

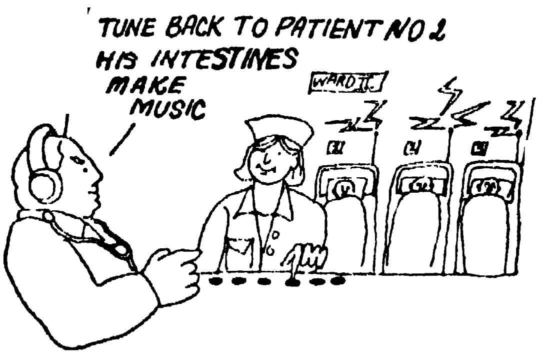
Gulp down a transmitter

And it will tell your doctor which is the trouble spot in your digestive tract. The mini transmitter, another space spin-off, is used in bed-rest studies simulating weightlessness of space.

Developed at the Ames Research Center, Moffet Field, California, USA, by Thomas Fryer and Jack Pope, the pill has been modified by engineer Richard Westbrook. The mini-transmitter, the size of a vitamin pill, is coated by a protective layer to tolerate the digestive juices. It takes about 48 hours to pass through the whole system. But with a low residue diet, this period can be prolonged to seven days. The battery's life-span is 52 to 76 days. The transmitting antenna can be placed on the bed or the patient's waist band.

The pill detects and transmits small temperature variations. (Localised high temperature is the sign of either infection or disorder.) It can be used to record and transmit other information, too.

Hand assembled at present, one pill is priced at $110. When mass production begins, the price will come down to 50 cents. Work is being done to reduce its size further and increase its transmitting power.



into seven batches and assigned a particular type of programme for each group. Cartoons, educational TV, sports, comedies, drama, and about everything else were allotted one each to the first six groups. The seventh group had no instructions. The study lasted three weeks.

Creativity tests carried out before and after the experiment showed that only the seventh group improved. The rest — including the educational TV group — showed a decline in all creative abilities except verbal ability. The cartoon-viewing group fared worst.

When TV replaces social activities in children, creativity lapse occurs. It is the mingling with real people that enhances intellectual development, says Stern.

And no play worsens it

Phyllis Dolhinow of the University of California, Berkeley, USA, says active play is essential for proper development. In tribal human societies, children play the roles they assume in adult life. An average American child sits uninvolved in front of the TV. This develops passivity.

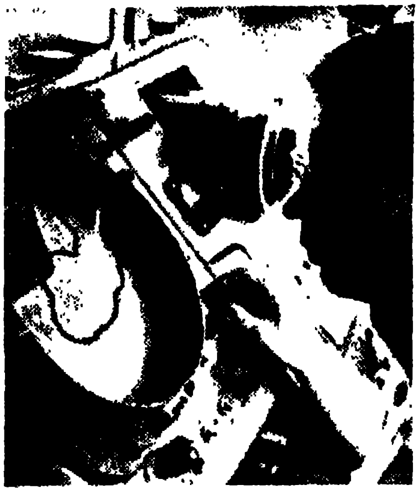
Concluding from her study of non-human primates, Dolhinow, an anthropologist, says, play is extremely functional. . . . "It isn't goalless wasted activity, but rather a very valuable pastime that doesn't really pay off until adult years."

Paper slates

The Regional Research Laboratory at Jorhat in Assam, has brought out an inexpensive long-lasting slate made of paper.

These unbreakable slates are lighter in weight and do not lose the abrasiveness soon. A special chemical mixture is coated on paper-board. The samples produced at the Laboratory are claimed to match those produced abroad. The extremely brittle rock slates were replaced partly by coated metal ones. These lost their abrasiveness quickly and rusted. The paper slate, estimated to cost about 58 paise for a 30 × 30 cm piece, may be the answer.

Command the hail . . .



Hail cloud on the radar screen

The Russians are now up in arms, literally, against the clouds — the hail-bearing ones. The reason: hail is a major crop destroyer. Now they have a radar vigil to spot out hail clouds brought by cold damp air. The watch-tower intimates the artillery, and the gunmen fire at the clouds from anti-aircraft guns located at several points in the field. The shells contain certain non-toxic chemicals that convert hail to rain. About 243,000 hectares of land are protected by one team.

At the Fergana Valley in Uzbeckistan, USSR, the hail fighting team has successfully protected cotton fields. At present four million hectares are covered by the scheme. By 1975, the protected area will be six million hectares.

Anti-aircraft guns firing the hail clouds

. . . the lightning

The celestial electric discharge often brings disaster in its wake. Scientists of the National Oceanic and Atmospheric Administration, USA, are trying to control lightning by bleeding away the electrical energy of the clouds.

Aluminised nylon chaff is spread on the storm clouds by aircraft. This dissipates the energy by introducing a conductive layer between the opposite charged poles of clouds. The nylon chaff ionises the air and makes it a semi-conductor. The electricity is thus bled off by the corona effect.

. . . and the hurricanes

Evaporation on the ocean surface gives hurricanes their drive. The National Oceanic and Atmospheric Administration scientists have successfully curbed evaporation by blanketing the ocean with a thin chemical film. This biodegradable film consists of linoliec acid, polyvinyl alcohol and polyvinyl acetate derivatives. The film is a few molecules thick and effectively controls the vaporisation. It acts as a physical barrier and also suppresses the small waves and ripples. According to some scientists, the latter property is more effective in curbing evaporation.

In an experiment on the Gulf Stream off the Florida coast in USA, a continuous sheet was spread over a 2·5 square km area. The film lasted for four hours and reduced high frequency waves. Further improvements are under way to make the film longer-lasting.

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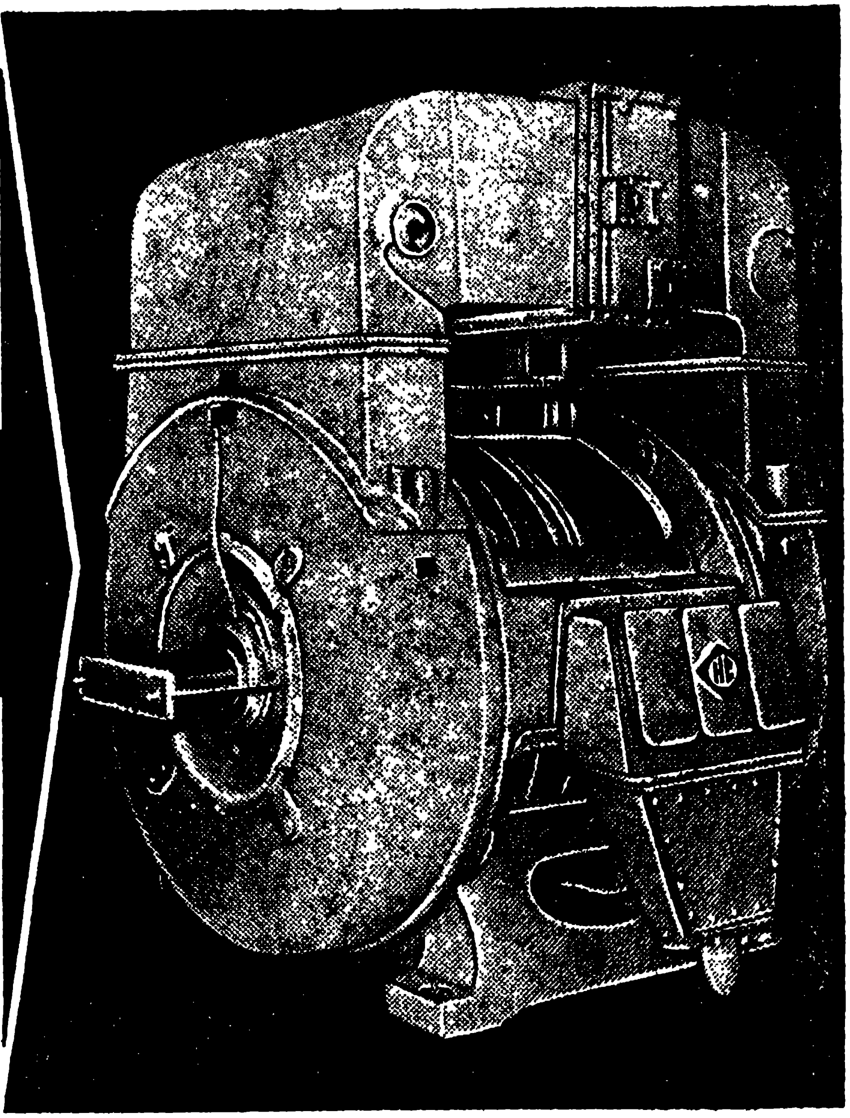

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BHOPAL

Newfields

total energy concept for more power

Power needs can be reduced substantially if we can make better use of fuels

DURGESH CHANDRA
P. R. SRINIVASAN

IT is almost certain by now that, though the Fourth Plan envisaged to produce 23 million kilowatts (kW) of power by 1973-74, the actual capacity is not likely to exceed 19 million kW. That would mean a shortage of 40 per cent, four per cent higher than even in the first three Plans. Power shortage has thus become a chronic feature. And an early end to the problem is nowhere in sight.

Meanwhile, energy requirements in the country have been increasing rapidly. In 1970, the total demand, including the domestic sector, was of the order of 22 million kW. This is expected to go up to 40 million kW by the end of the decade. The per capita consumption, which was 38 kW hours or units in 1960, rose to 78 units by 1968-69. By 1978-79, this is estimated to rise to 185 units. Even so, this compares poorly with the per capita consumption of countries like Belgium (2,444 units) and Austria (2,471 units) and the world average of 1,300 units.

Efficient energy generation and utilisation is a primary need in a developing country. In the long run, the solution lies in setting a long-term target, say for the year AD 2000, and working towards it through phased short-term programmes, and simultaneously developing new and more efficient sources of power like nuclear, including fusion, solar, geothermal energy, etc. Planning for power in India, however, has been haphazard and piecemeal. While the duration of our plans is only five years, even to build a 200 MW thermal station takes about seven years.

It is now proposed to increase power generation capacity from 49·9 billion units to 125 billion units by 1978-79, the end of the Fifth Plan. This would mean an addition of 5,000 MW every year, and an investment of Rs. 5,000 crores, which is very high indeed.

That there is an urgent need for such a massive investment is beyond doubt; ready availability of adequate power is essential for the rapid growth of industries. But the question is: can we find this money, given our scarce resources ? Since power generation is in the public sector, all this money has to be found by the Government. It is only proper, therefore, that we explore certain alternatives and means of reducing this burden.

Can we not minimise the demand for power on public utilities by making better use of fuels in factories and industrial plants ? A study shows that the demand for purchased energy from public utilities can be reduced by 20 per cent or so without in any way affecting the present level of industrial activity, if we apply the total energy concept. This way, it is possible to generate 10,000 MW of additional power within a short time of four to five years, and tide over the immediate crisis.

But what is total energy concept ? This involves making optimum use of fuels and

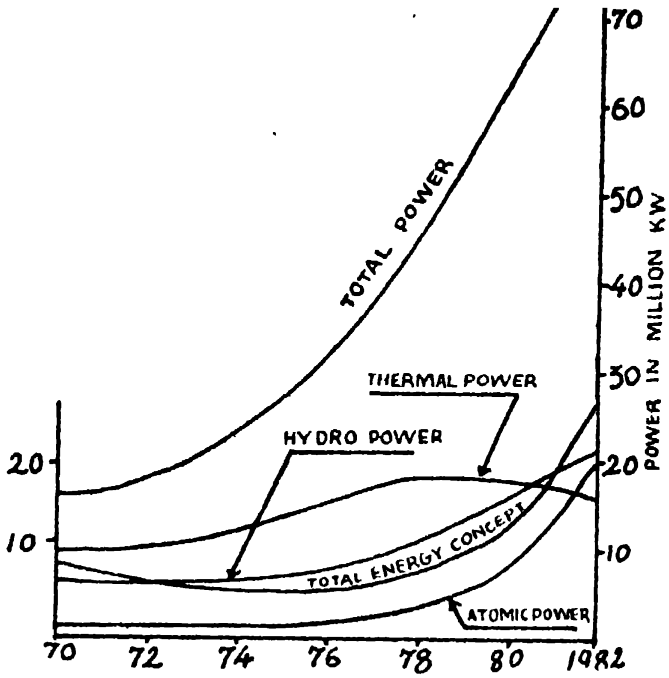


Fig. 1. Projected development of power, 1972-1982

cascading energy from one form to other in a system. This would reduce the need for purchased energy for the system to the minimum. Sometimes, such a reduction could be substantial. Heat energy or steam is used in most of the industrial systems, both manufacturing and processing. But the different sub-systems in a system require different levels of heat energy, and much of the steam is wasted after the primary use for heating, even when a lot of heat is still left unutilised. It is possible to recover and recycle or cascade this energy flow from one system to the other till it is economical to do so, or generate power using this " waste " steam. The method of cascading or recycling would differ depending on the threshold heat requirements of each sub-system. The concept may thus dictate different approaches for different systems.

AT UNIT LEVEL, and to a limited extent, the concept has been applied in energy-intensive industries like steel plants and metallurgical and refractory industries. But it is yet to find wider use in other major industries like fertilisers, petroleum refineries, chemical complexes, etc even in the developed countries. The reason is not far to seek. The availability of cheap power in adequate quantities was so far taken for granted by the industrially advanced countries. East Asian oil on which the western industrial nations depend heavily is now coming under increasing political and economic pressure. This has prompted them to look for means of reducing energy consumption. And it is only in the last five or six years that one has been hearing about the total energy concept.

In any case, a decade or two ago, when energy was cheap, none would have thought of installing a heat recovery device in direct fired heaters in refineries or chemical plants. That would have meant more maintenance expenditure. Now efforts are being made to recover heat from such direct fired heaters. And what was at one time uneconomical is becoming economical, depending on the price of energy. The price of purchased energy would also influence the extent to which energy can be cascaded or recycled within the system.

So far we have discussed the concept of total energy as applied to heat energy only. However, industries require both heat energy and electrical energy. While heat energy can be produced by burning almost any organic material, to produce electrical energy we need a hydel, thermal or a nuclear station, using water, coal or oil and radioactive materials like uranium as the energy sources, respectively. Of these, the hydro station is quite efficient, while even the most efficient thermal plant has an overall efficiency of only 40 per cent.

THE EFFICIENCY with which heat energy can be converted into work depends on the temperature limits within which an operational cycle works. (The Second Law of Thermodynamics tells us that to convert heat energy into work, one requires a high temperature source, a low temperature sink, and a cycle of conversion operations within these limits.) The greater the limits, the higher is the efficiency. The efficiencies of conversion of heat into work in some important operations are: steam engine (non-condensed) 5 per cent; low temperature condensing steam cycle 14-20 per cent; high temperature condensing steam cycle 35-40 per cent; automotive engine (petrol) 30 per cent; diesel engine 35 per cent; gas turbine 55 per cent; magneto hydrodynamic (MHD) plant superimposed on a steam plant 50-55 per cent; and fuel cell 85-90 per cent.

Apparently, except in the fuel cell, nearly half or more of the heat input in all devices is wasted into the atmosphere. And though the MHD system (see " MHD—the promise and the problems ", p. 13, SCIENCE TODAY, Dec. 1972) combined with the conventional steam cycle seems to be superior in conversion efficiency, it is still in an experimental stage, and it would be quite some time before one could think of a large MHD plant.

Next comes the gas turbine. With a conversion rate of around 55 per cent, it is more efficient than most of the modern, efficient steam plants. But the gas turbine too has not found wide applications beyond a certain capacity, say 50 to 55 MW, because the auxiliary units, mainly the gas compressor, consume extremely high power — over 60 per cent of the total power produced by a gas turbine power generating unit. Thus the net power available is only 40 per cent. Besides, even a slight fall in the performance of the compressor for some reason or other, reduces the net power output drastically. On the other hand, a coal or oil-fired steam cycle for power generation needs very low power, of the order of 2 to 3 per cent of the total output, for its auxiliary units like water feed pumps, fuel handling equipment, fans, etc. Hence for large electrical power generation, the steam cycle is yet unrivalled. Maybe, fusion power will challenge this by the end of the century.

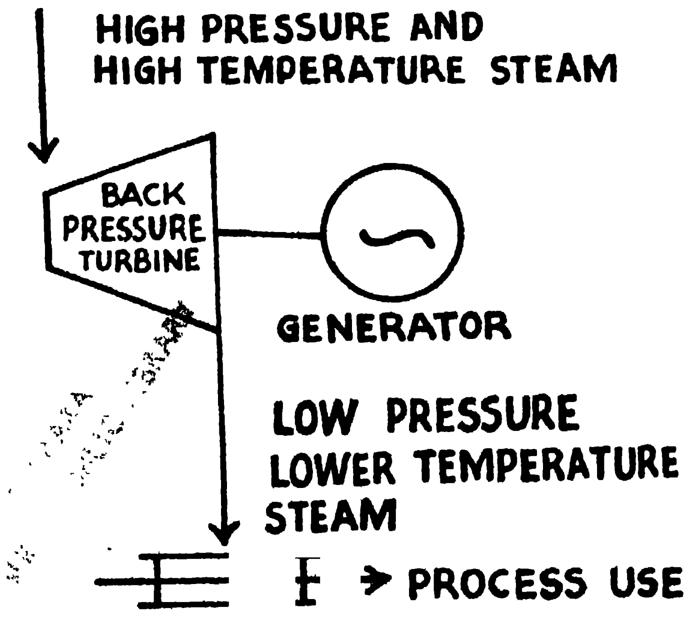
Steam, however, is not a suitable fluid from the point of view of thermodynamic efficiency, or the rate of conversion of heat into work. Its saturation temperature is very low even at high pressures; and for high thermodynamic efficiency, as mentioned earlier, we require high temperatures. For example, steam reaches saturation point at a temperature of 373°C at a pressure of 218 atmospheres while the saturation temperature of mercury is 318°C at atmospheric pressure alone. This means mercury can store more heat and consequently give more work too.

SOME THERMAL PROPERTIES OF STEAM AND WATER

When steam is used inside a heating surface like coil, pipe or jacket, it is the latent heat that is available for useful work. This table gives the representative thermal properties of steam. It is interesting to observe that the latent heat value is more at lower pressures.

Pressure: ins vacuum or lb/sq in	Water boiling temperature °F	Sensible heat in water Btu/lb	Latent heat of steam formation Btu/lb	Total heat saturated steam Btu/lb
Vacuum				
29·0 in	79	47	1050	1096
27·0 in	115	83	1029	1112
25·0 in	134	102	1018	1120
20·0 in	161	129	1002	1131
10·0 in	192	160	983	1143
Atm. pressure	212	180	971	1151
100 lb	338	309	882	1191
200 lb	388	362	833	1200
420 lb	453	433	772	1206
1000 lb	546	545	647	1192
2000 lb	637	674	461	1135
3192 lb	706	896	0	896

Fig. 2. Power generation and process steam supply using the back-pressure or pass-out turbine



Even so, steam is used extensively for power generation because, water, which gives steam, is available cheaply and abundantly. Other organic fluids or mercury which are more preferable from the point of view of thermodynamic efficiency are expensive and pose their own set of problems in practical use.

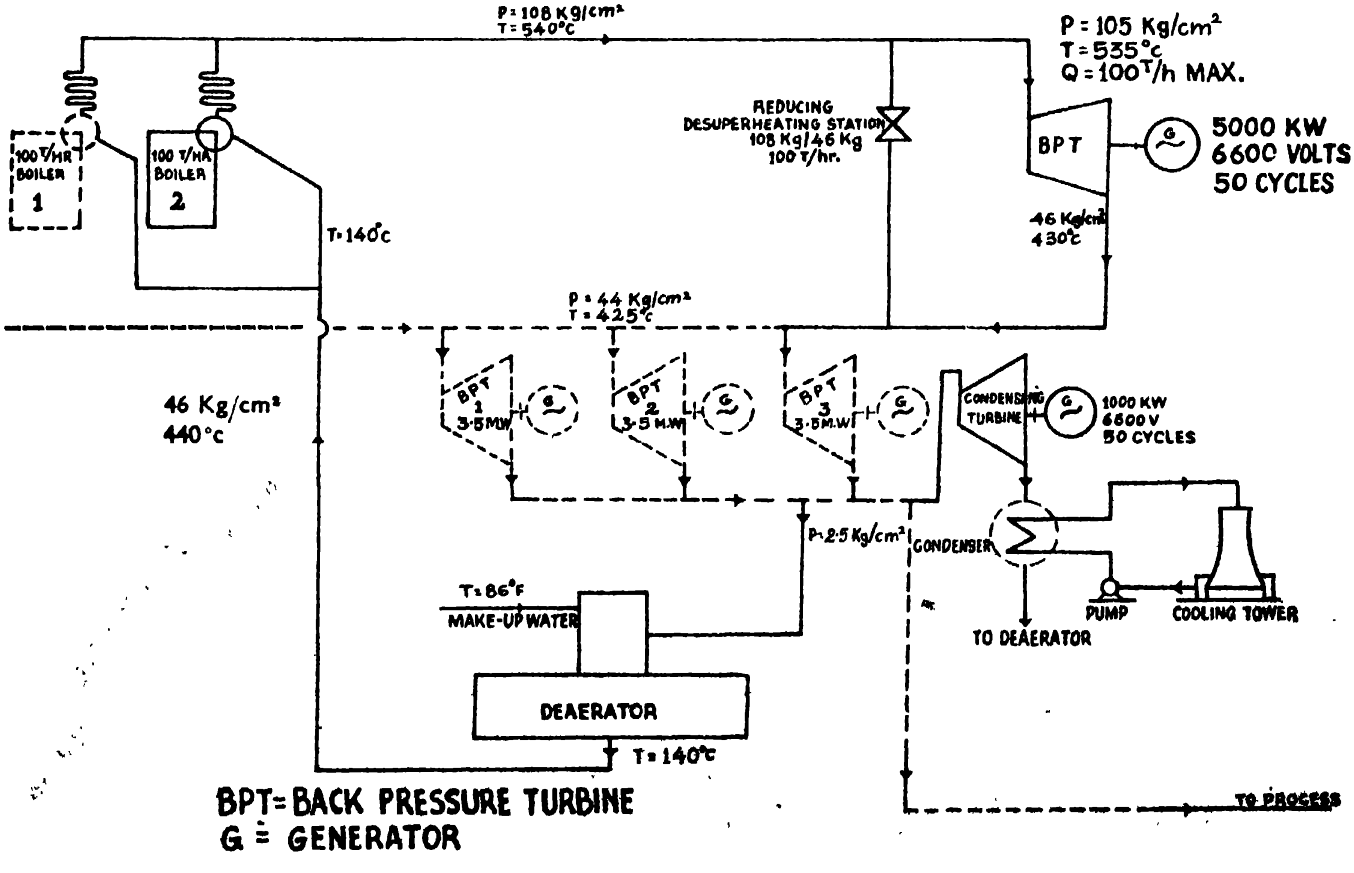
IF ONE LOOKS up the steam table (see table above), one would observe that the total heat of steam is very nearly independent of the pressure at which it is generated. It means that the amount of fuel spent is more or less the same in raising, say 1 kg, of steam either at atmospheric pressure or at 100 atmospheres. It is therefore worthwhile raising steam at the highest temperature practicable. Then it is possible to expand high pressure steam in either a back-pressure or a pass-out turbine to generate electrical power and at the same time provide the exhaust steam for the process as illustrated in Fig. 2.

The extent to which firm electrical power could be generated by this method obviously depends not only on the quantity and pressure of steam required for the process, but also on the quantitative and qualitative nature of the steam demand for the process. Using the total energy concept in industries requiring large quantities of steam and electrical power simultaneously would therefore mean generating steam at the highest possible pressures and then expanding it in a back-pressure turbine to a pressure dictated by the process demand. There will be no or little extra expenditure on fuel, but there will be some capital investment in a high-pressure boiler and a back-pressure turbine connected to an alternator. Since the high-pressure boiler has a higher fuel efficiency, one could, in fact, reasonably expect the fuel expenditure to decrease marginally, depending, of course, on the existing system. And while one would expect fuel consumption to increase in a typical case by 6 per cent, an increased boiler efficiency, from 72 per cent to 80 or 85 per cent, would in effect result in a net saving in fuel. For example, steam raising efficiency in boilers in a chemical factory using the total energy concept would improve from 72 to 83 per cent, the overall turbine house efficiency from 19 per cent to 30 per cent and the pass-out generation efficiency would go up from 60 per cent to 80 per cent. The thermal efficiency of the total energy system will be 85 per cent, compared to 35 per cent in most modern thermal power plants.

Thus steam, while it may have some undesirable properties for exclusive power generation by high temperature, has some unique advantages where combined steam and electrical power is required. In paper and textile mills, refineries, fertiliser units, petrochemical complexes and chemical and rayon industries, there is a simultaneous demand for electrical energy for operating the plants and steam for the chemical process. And it is practicable to combine the steam and power cycles; power could be generated in a back-pressure or pass-out turbine and heat energy from the exhaust steam used for process demands, with a single source. In fact, this is being practised in some large chemical plants in the country.

Paper mills in Britain have greatly benefited by this concept. Also, according to a recent British study "heating bills could be cut by 40 per cent and electricity charges by 25 per cent with cleaner environment thrown in for good measure if the electricity generating boards would agree to sell both electricity and hot water or steam for domestic and commercial heating". In fact, this is precisely what is done in the little town of Wuppertal in West Germany. The entire steam and hot water demands of the industries in the town as well as domestic requirements are met by a single

Fig. 3. Diagrammatic scheme of the total energy concept applied in a chemical process plant. Broken lines show the existing system with partial utilisation of the concept. Continued lines show the additional requirements to enhance power generation with full application



power station with high-pressure boilers and back-pressure turbines.

Tokyo in Japan too is planning to set up several total energy steam stations. High pressure boilers will deliver steam at pressures in excess of 230 atmospheres to back-pressure turbines; the turbines will exhaust steam at five to ten atmospheres for producing high-pressure hot water needed for space heating of the multi-storeyed buildings, big hotels and households in a given area. In such an event, individual heating units consisting of low-pressure boilers and water heaters now installed in multi-storey buildings and big hotels would be replaced and steam supplied from a common source outside. Such a system, it is claimed, will also cut down atmospheric pollution since a large number of small and not-so-very efficient low-pressure boilers will be replaced by a single, large, highly efficient high-pressure boiler with automatic controls. There is thus a trend towards total energy schemes all over the world. Though there may not be much of steam demand for space heating in our country, there will certainly be a substantial demand for air-conditioning and refrigeration loads.

IN ORDER TO find out the potentialities of the application of the concept in Indian industries, the authors carried out a sample survey of 25 large industries. The survey covered integrated steel plants, integrated paper and pulp mills, rayon industry, composite textile mills, heavy chemical plants, refineries, fertiliser plants and process industries.

It indicated that in most of the units the steam pressure from the boilers was about 27 atmospheres and the temperature was about 370° to 400°C. In a few industries, this was around 40 atm and 400°C; these had generally been put up in the 1960's. Even many of the industries set up in the last few years had steam pressures around this figure. Only one or two industries had boilers generating steam at pressures and temperatures close to those prevailing in modern thermal power stations.

In an industry where steam consumption is more than 50 tons per hour, it should be quite possible to generate steam at 100 atm and a temperature of 545°C and to develop the system for the generation of 12 to 15 MW of power along with process steam use. Where steam consumption is between 25 and 50 tons/hour, it may be economical to generate steam at 45 atm and 450°C. Where the consumption is still less, such industries can be grouped together and located at a common industrial site; and a centrally located thermal power station for steam and power can be then installed.

Through these measures, one can reasonably expect an additional generation of 10,000 MW or 10 million kW of power in the next five years. And to that extent the burden on power supply companies will be relieved. They can then easily meet the demands of other new industries or the expansion programmes of the existing industries. This would raise production. The cost of power produced using the total energy concept may not exceed 10 paise per unit.

For some historical reasons, certain regions in the country have a very high density of industries. We could take advantage of this fact and explore the possibility of setting up a common total energy steam station to supply process steam to all the industries in a given area and at the same time generate electricity also. For instance, in Amritsar, there are about 150 smallscale textile/woollen processing mills which require steam at a low pressure for processing. The possibility of having a total energy station for supplying steam to these units can be explored. Other cities, towns and industrial areas which offer good scope for establishing total energy stations include the Trombay area, Thana-Belapur area, Kalyan-Ambarnath area (all near Bombay), Bombay City, Ahmedabad, etc.

BESIDES COST reduction, there are several other advantages in a total energy steam station. Important among these is the reduced atmospheric pollution. Instead of a large number of small-capacity boilers polluting the atmosphere with their black smoke (as is the case at present), one could have one big boiler fitted with automatic controls. This would not pollute the atmosphere. And since heat energy is recycled within the system, thermal pollution too is minimised.

The concept will be beneficial not only at unit level but also at inter-unit or regional level. Some of the obvious advantages are: (*i*) there will be a relief to the public exchequer to the extent of Rs. 400–500 crores, because this investment in high-pressure boilers would have to be made by large industries whether in public or private sector and this investment could be diverted from the capital-intensive power sector to labour-intensive sector with maximum employment potential; (*ii*) saving in transport of fuel because of the additional generation of electricity locally without using

Some constraints...

TO derive the fullest benefits from total energy concept, certain organisational and procedural changes are necessary. Some of these are given here.

The State Electricity Boards and Central Government should allow large industries requiring a substantial amount of steam and electrical power simultaneously to generate their own electricity using captive power plants. However, power generation by the industries could be restricted to the extent necessary to meet the process steam demands. Further, the Government may allow large industries to install only back-pressure turbines or pass-out turbines with not more than 10 per cent of the quantity of process steam being allowed to be condensed. Purely condensing turbo-alternators (only for power generation) need not be permitted to be installed in the industrial sector. Since the gap between supply and demand of power is considerable now, Electricity Boards need not be conservative in this respect.

The Government should set up a separate corporation for meeting expeditiously the requirement of the industrial sector in high-pressure boilers, back-pressure or pass-out turbines and reduction gears, as the existing units in the public sector are fully booked with orders for the major power projects coming up in the next five to ten years. The survey, mentioned in the main article, indicates that the estimated demand from the industrial sector would justify the establishment of such a unit.

State Industries Departments should think of setting up functional industrial estates for specific types of industries requiring steam and electrical power simultaneously and set up a total energy steam station in such an estate. Such a system would reduce atmospheric pollution from individual units, and it is also then possible to have a common effluent treatment facility.

Large industries, being planned now as well as the existing ones, should be encouraged to generate steam at the highest practicable pressure and temperature.

Research and development efforts in the field of heat recovery should be intensified. Development efforts aimed at cleaning of hot gases should be initiated. The development of total energy heater, namely, small-sized gas turbine, to replace direct or indirect fired heaters, should be taken up immediately. An institution at the national level to impart training in all the aspects of industrial boiler and turbine operation, waste heat recovery, etc should be established. This institution should also teach latest maintenance management practices and methods.

And finally, the question of levying duty on fuel oil used for electrical generation for self-use in total energy steam stations whether in the private or public sector may be examined afresh from all angles.

extra fuel. There is also a net reduction in the fuel input in a given region with total energy stations because steam and electricity demands are integrated; (*iii*) there will be a net saving in transmission losses because the captive power plants of large industries will be able to meet a larger portion of their electrical load. For every kW of power saved in transmission losses, nearly 2 to 3 kW of power in the form of fuel can be saved on the input side; and (*iv*) there will be a net saving in the energy at the national level for a given requirement of heat demand and electrical energy.

There are, however, several constraints at present in exploiting the concept to its fullest extent. First, high-pressure boilers and back-pressure turbines are not readily available in the varying capacity ranges required by the industries. The high-pressure boiler units at the Bharat Heavy Electricals Ltd (BHEL) are making mostly power boilers at present. Similarly, even though BHEL's other units are equipped to manufacture back-pressure turbines and alternators for large industries, they are at present not in a position to meet the demands from large industries for such equipment within a reasonable period of time, say two years, as their order books are already full.

If, therefore, there is a simultaneous demand for high-pressure boilers and back-pressure turbines from large industries, it would be well-nigh impossible for the existing manufacturers in the public or private sector to supply these. Therefore, a separate manufacturing unit, either in the private or public sector, should be established specifically to meet the demand for high-pressure boilers of medium capacity (say up to 100 tons/hour), back-pressure turbines and alternators (ranging in size from 1·5 MW or so to 30 MW) and reduction gear units. Till such time as the Government is able to set up the manufacturing facilities, it would be advisable to allow the import of these equipment on a quick delivery basis to tide over the current power crisis.

Durgesh Chandra is Chairman of the Subgroup on Total Energy, National Committee on Science and Technology (NCST). A chartered mechanical and electrical engineer, he heads the engineering division of a chemical process firm in Bombay.

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The authors wish to point out that the opinions expressed in this article are entirely their and do not reflect the views of their organisations, nor of the NCST.

round-up of research

ENDOCRINOLOGY

Hormones and Homosexuals

THE idea that hormone changes rather than psychological effects contribute to the genesis of homosexuality in humans has been given further impetus by Dr. M. S. Margolese, a Professor of Medicine at the University of California Medical Centre, Los Angeles, USA and Dr. O. Janiger, a lecturer at the Department of Psychiatry and Human Behaviour at the College of Medicine of the University of California, Irvine, USA. They have shown a significant difference in the ratio of the male hormones androsterone and etiocholanolone excreted in urine by homo- and heterosexual males (*British Medical Journal*, *3*, 207, 28 July 1973).

The chief male hormone testosterone is largely secreted by the testes. The adrenal cortex lying above the kidney also secretes a small amount of this hormone, and dehydroepiandrosterone (DHA) a testosterone precursor. The liver converts testosterone by reduction to androsterone and etiocholanolone. These two compounds, together with DHA, make up the principal components in the urinary 17-ketosteroids (17-kS). Over a 24-hour period, the average excretion of 17-kS from a normal male adult is about 14 mg.

The American doctors studied a total of 63 male subjects. The homosexuals were obtained from various homosexual organisations, while the heterosexual controls were drawn from college students. Each subject was interviewed and classified, using a modified Kinsey sexual inventory, into one of six groups from exclusively heterosexual (0-1) through degrees of homosexuality (groups 2, 3 and 4) to predominantly and exclusively homosexual (5 and 6). Data on the frequency of their sexual activity — defined as any action that resulted in orgasm — and on factors such as parental age and incidence of homosexuality in their families were also obtained. The subjects also underwent a physical examination to detect any secondary sexual abnormalities and the presence of disease.

Each subject submitted a 24-hour specimen of urine which was analysed for 17-ketosteroids, androsterone and etiocholanolone. After the exclusion of unhealthy subjects, the biochemical studies were done on 23 homosexuals, 24 heterosexual controls, 9 intermediates (Kinsey 2, 3 and 4) and 1 transexual.

No significant differences were found between homo- and heterosexuals in physical factors such as genital size, distribution of pubic hair or in age of parents at the subject's birth. Nor was there any difference in the frequency of their sexual activity before urine collection. There was, however, a significant difference in the incidence of homosexual relatives in the immediate and extended families between the two groups. Biochemically, the total 17-kS excretion in the urine was found to be within normal limits in both the homo- and heterosexuals. The 17-ketogenic steroids measured in 6 homosexuals were also within normal limits. However, there was a variation in the ratio of androsterone to etiocholanolone (A/E). For 23 of the 24 controls, the ratio was greater than unity, whereas in 14 of the 15 Kinsey scale 6 subjects, the ratio was less than unity.

Drs. Margolese and Janiger point out that though the ratio A/E less than unity may be a necessary condition for homosexuality, it is not a sufficient condition, since non-healthy subjects also show a A/E ratio less than unity. However, the significance of their study is that this ratio differs from the controls only in the exclusive homosexuals. They conclude that their results strengthen the hypothesis that the metabolic pathway resulting in a relatively high androsterone value is associated with sexual preference for females by either sex, whereas a relatively low androsterone value is associated with sexual preference for males by either sex.

NEUROBIOLOGY

Learning Causes Changes in Brain Chemicals

THE rush of biochemists to brain research may be said to have begun with the cracking of the genetic code by Dr. Francis Crick and his colleagues in the 1950s. The idea that hereditary information is coded as chemical units led a number of biologists to the next logical supposition that memories may also be encoded in the sequences of the chemical components of nucleic acids or proteins. The role of RNA in learning is fairly well recognised (see SCIENCE TODAY, p. 28, August, 1969).

There is now strong evidence that the structure and function of parts of the central nervous system in many species is modified by experience. This has been particularly shown in the neurones of the visual pathways in animals reared in darkness and other environmental conditions. Do similar modifications take place during learning which is a process of acquisition and storage of information?

A review of the results of experiments using probably the only rational and least controversial biochemical approach to the problem of neural changes during learning has now been reported in *Science* (*181*, 506, 10 August, 1973) by Prof. S. P. R. Rose of the Department of Biology, Open University, Bletchley, Buckinghamshire, England and Drs. P. P. G. Bateson and G. Horn of the Departments of Animal Behaviour and Anatomy, respectively, of the University of Cambridge, England.

In their experiments they have used a kind of learning that would be easy to define and measure, known as imprinting. In this process, first described by the ethologist Konrad Lorenz, birds follow (become imprinted to) the first moving object they see (usually mother) and the longer they follow it, the stronger is their tendency to pursue it rather than anything else.

By using freshly hatched chicks and exposing them to a flashing orange light known to be highly effective as an imprinting stimulus, they were able to show that during this process there is a significant elevation of biochemical activity in the forebrain roof region. The activity was determined by injecting into the chicks before training radioactively labelled (tritium) lysine or uracil. After training, increased radioactivity was found in the brain region, most probably as a consequence of incorporation of uracil or lysine into macromolecules like RNA or protein, respectively.

It is possible that these biochemical changes are caused by general sensory stimulation as such at the time of training. In their recent experiments *Science*, (*181*, 576, 10 August, 1973) they have, therefore, attempted to correlate learning with the biochemical processes in the brain in a more quantitative way.

Four groups of newly hatched chicks were on the first day trained to run towards the flashing orange light for 20, 60, 120 or 240 minutes. The chicks ran, in fact, on a rotating wheel so that the amount of running could be measured. They were then retrained for 60 minutes on the second day. The British biologists reasoned that the more learning the chick does when it first sees the object to which it becomes imprinted, the less learning it will have to do the next time. If there is less learning on the second day, then there should be less synthetic activity in the brain. In accordance with these assumptions, they found that as the length of exposure on the first day increased, the incorporation of tritium labelled uracil into acid-insoluble substances in the anterior part of the forebrain roof decreased on the second day. No such relationship was found in any other region of the brain.

They conclude that, taken together, the results of all their experiments are consistent with the view that the biochemical changes in the forebrain roof are linked with the acquisition process involved in learning.

MEDICINE

Tests for Detecting Cancer

ADVANCES in the science of immunology, the suggestion that cancer may be caused by viruses and that viruses can exist in a latent form in human cells are all being combined together in the development of mass screening tests to identify people who run a particularly high risk for the development of tumours.

One of the first substances investigated was carcinoembryonic antigen, (CEA) so called because it can be extracted both from cancers and from the lining of embryonic intestines. Three years ago, Field and Caspary (*Lancet*, *2*, 1337, 1970) used the macrophage electrophoretic mobility (MEM) test for the detection of cancer. Both these are tests based on the premise that cells from both animal and human tumours differ in their antigenic properties from normal cells, and the changes may evoke immune responses in the host. But neither the CEA nor the MEM test is an ideal cancer antigen test, since both use substances which are also found in patients with diseases other than cancer.

Five years ago, Morton and Malmgren (*Science*, *162*, 1279, 1968) described a cytoplasmic antigen uniquely associated with human sarcomas. Cells taken from such tumours and grown in culture were seen to fluoresce when tested by an indirect immunofluorescence technique after the addition of serum from sarcoma patients. The fluorescence was believed to be due to antibodies from the patient's serum attaching themselves to the antigens in the cells. Antibodies were, in fact, demonstrated in a high percentage of sera from patients with various histological types of sarcomas, their family members and close associates. In contrast, few sera from normal individuals were found to react with the same antigen. Assuming that the antigens belong to a virus that causes cancer, the observations were explained as an indirect evidence for the viral aetiology of human sarcomas.

Drs. B. Mukherji and Y. Hirshaut of the Division of Cell Biology, Sloan-Kettering Institute for Cancer Research, New York, USA have now shown that the antigen is not unique to sarcomas, but is found widely distributed in patients with other tumours as well. (*Science*, *181*, 440, 3 August 1973.) As previously, antibody to the antigen was detected in the serum of 72 per cent of patients suffering from sarcoma and their relatives, as compared to only 10 per cent of normal persons; 20 to 53 per cent of patients with carcinoma of breast, lung, ovary and gastrointestinal tract also revealed the presence of the antigen. Interestingly, the incidence of the antibody was not very different from that of the normal population in the serum of patients with leukaemia and lymphoproliferative malignancy.

By culturing various kinds of cells with serum proved to contain antibody, they also showed that embryonic tissue and skin, both of tumour bearing and normal individuals, also contained the antigen. The fact that the antigen appears in embryonic and growing tissues suggests that it may be what has become known as a foetal antigen. Drs. Mukherji and Hirshaut are of the opinion that it is unlikely that a single virus would be responsible for such a broad range of tumours and, hence, the antigen is a poor candidate for an oncogenic virus-associated agent.

They suggest that, in keeping with other foetal antigens detected in cancer patients, the antigen may represent the product of cell derepression. The presence of antibody to this antigen in patients with tumours and in their relatives may mean that these people have depressed cells which might become cancer cells under the influence of some cancer-causing agent, and that, therefore, they are at particular risk.

It is worth noting that both MEM and the immunofluorescence test give negative results for patients known to be suffering from leukaemia. Indeed, none of the early warning tests are at the present juncture capable of distinguishing completely between cancer victims and healthy people. If, however, they can be perfected, it would be outstandingly valuable in screening susceptible and 'at risk' populations, provided also that they can be developed in such a way as to be routinely applicable to reasonable numbers of patients.

LOW TEMPERATURE PHYSICS

Towards Absolute Zero

CAN temperatures close to absolute zero (0°K = – 273°C) be reached and measured? It is known that matter attains very special properties at these temperatures, like superconductivity, superfluidity, etc. The recent discovery that liquid helium-3 undergoes two separate phase transitions near 2 mK (0·002°K), evidently with superfluid properties (see SCIENCE TODAY, p. 20, May 1973), is a case in point.

The attainment and measurement of temperatures below 1 mK is a formidable problem. However, this has now been achieved by Drs. M. Kolac, K. Svec, R. S. Safrata, J. Matas and T. Tethal of the Nuclear Physics Institute of the Czechoslovak Academy of Sciences. The details of how they reached a temperature of 0·86 mK by adiabatic demagnetisation of magnetically diluted cerium magnesium nitrate (CMN) are reported in the *Journal of Low Temperature Physics* (*11*, 297, May 1973).

The technique of adiabatic demagnetisation of paramagnetic crystals has been in use in low temperature physics for nearly four decades. The normal random orientation of the net magnetic moment possessed by the magnetic ions in these crystals, due to the thermal vibrations of the lattice, can be aligned in a particular direction by applying a magnetic field; this will reduce the entropy of the system. If the crystal is then thermally isolated, so that its entropy cannot change, and the magnetic field slowly reduced to zero, it will cool because in zero magnetic field its entropy will correspond to a very much lower temperature. The ultimate temperature which can be attained in this way depends on the mutal interaction of the magnetic ions. In order to minimise these interactions, crystals of very large unit cells where the ions are well separated from each other are chosen. In pure cerium magnesium nitrate, for example, interactions between the magnetic cerium ions limit the final temperature to about 2 mK.

A team of physicists from the Argonne National Laboratory, USA had, however, suggested (*Physical Review*, *187*, 273, 1969) that an alternative way of reducing the interactions between the magnetic ions is to replace most of them by ions, which though chemically similar, are non-magnetic. They had estimated that, with about 90 per cent of the cerium ions in CMN replaced by lanthanum ions, it might be possible to reach a final temperature near 0·7 mK.

Dr. Kolac and his colleagues have now experimentally confirmed this suggestion. As there is now no internationally agreed temperature scale in the region below 1 mK, the Czech scientists, in fact, measured a magnetic temperature T*, deduced from the measurements of the magnetic susceptibility of CMN which is assumed inversely proportional to the temperature (Curie's law). Using the magnetically diluted crystals, they reached a final T* of 0·86 mK, in reasonable agreement with the theoretical predictions of the Argonne group.

GEOPHYSICS

An Explanation for Mid-plate Tectonics

THE theory of plate tectonics is now capable of explaining a host of geophysical phenomena. It considers the Earth's crust or lithosphere as being made up of a number of rigid plates which move relative to one another. The boundaries between the plates are now recognised as being of three different kinds: (1) ridges, from which new crustal material spreads symmetrically, (2) trenches, at which plates descend back into the mantle and (3) transform faults, along which plates may slip relative to each other.

The bulk of the world's seismic and volcanic zones are not randomly scattered but form a series of linked patterns around the Earth's surface, now known to correspond to plate boundaries. These active bands have attained a physical rather than simply observational significance within the framework of the global tectonic theory. To put in a nutshell, plate boundary tectonics not only explains the location and cause of major seismicity and volcanism but also combines into a single conceptual scheme most of the internal processes changing the face and body of the Earth's lithosphere.

Though a relatively small proportion of the Earth's activity, volcanism and earthquakes also do occur well away from the plate boundaries. Oceanic island chains, continental graben and rift valleys, and features which pass from continental areas into oceanic parts of the same plate are particularly important. For example, one of the highly active seismic zones is centred near New Madrid (Missouri), USA, almost at the centre of a plate. The seismic activities in these mid-plate regions are not insignificant or local.

Are the concepts of global tectonics also capable of explaining the important processes taking place away from plate margins? Many geophysicists, during the last couple of years, instead of taking recourse to the classical plate tectonics, have tried to explain the mid-plate tectonics in terms of hot spots and mantle plumes. Hot spots are assumed as regions from where magmas in the upper mantle rise to the surface; the source of the magma is solid state convection plumes rising from the lower mantle.

While the existence of these phenomena is still under debate, Dr. D. L. Turcotte of the Department of Geological Sciences, Cornell University, Ithaca, (New York), USA in collaboration with Dr. E. R. Oxburgh of the Department of Geology and Mineralogy, University of Oxford, England, has tried to explain the mid-plate tectonics in terms of the well-known tectonic processes without recourse to any completely new phenomena. In an article in *Nature* (*244*, 337, 10 August, 1973) they argue that seismicity in mid-plate regions is the result of crustal extension due to tensional stresses — thermal stresses due to the cooling of the lithosphere or membrane stresses due to changes in the radii of curvature, or a complicated combination of both. According to them, it is difficult for a hot spot or plume to create regular tensional stresses.

K. A. Neelakantan

. and new processes

Protein from Cottonseeds — a Breakthrough?

SOYABEAN proteins have received wide attention in the USA as substitutes for more expensive animal proteins in many food products like candy, baked goods, processed meats and protein-rich carbonated drinks. A new protein, that from cottonseeds, is now available for similar uses. The main problem so far in preparing an edible protein from cottonseeds was to free it of a toxic pigment called gossypol (see "Food from Cottonseeds", p. 16, SCIENCE TODAY, Oct. 1970). Using a liquid cyclone process, based on the principle of differential settling of a slurry of the ground cottonseed kernels in hexane under centrifugal force, the Plains Cooperative Oil Mill at Lubbock in Texas is preparing a cottonseed flour of a high quality. It contains about 65 per cent protein and is very low in gossypol. The new plant will produce about 25 tonnes of this edible cottonseed protein a day at about 20 cents a pound (about Rs. 3·40 a kg). The product is marketed at 30 cents a pound (about Rs. 5 kg) while 70 per cent soyabean protein sells at 35–40 cents a pound (about Rs. 5·80 to Rs. 6·60 a kg). A bland taste and higher dispersibility in water are some of the advantages claimed for the cottonseed protein over that of soyabean.

What is interesting, however, is that the pilot plant development of this process was carried out at Hubli in India by Dorr-Oliver Incorporated with financial support from the US Agency for International Development. The hurdle in the commercial development of oilseed proteins in India is the generally high price of all processed foods, including those which use oilseed proteins; this puts such foods out of the reach of the common people who probably need them most in nutritional terms.

Cottonseed protein cannot compete in price with groundnut protein now commercially available in India. Groundnut has a high content of oil compared to cottonseed, and it is the high price of oil which in turn reduces the protein cost. Further, edible cottonseed protein is even more responsive to price increases of the seed than in the case of groundnut. The future of all edible oilseed proteins in India appears to be in finding much larger markets for the products. Now the outlets are mainly the low-cost foods being manufactured for government feeding programmes. But oilseed proteins could be used in making infant foods and in extending milk supplies.

K. T. Achaya

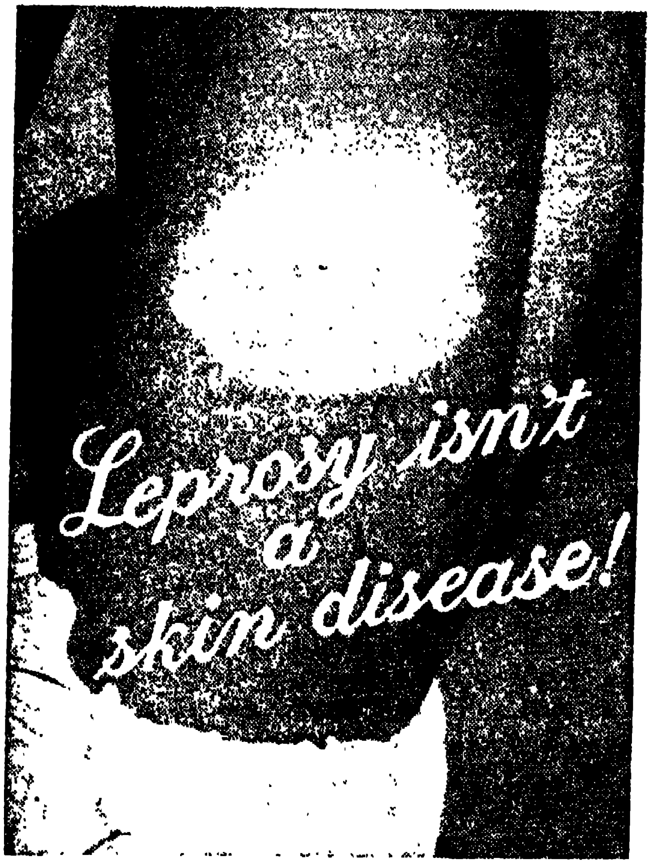
Flame-proofing Wool

THE incorporation of phosphorus and/or halogen additives is one of the methods of flame-proofing textile fabrics and carpets. Physical and structural modification of the fibre or at least its surface layer is an alternative to this method. This has been tried by Gilbert and Liepins of Camille Dreyfus Laboratory, USA (*Journal of Applied Polymer Science*, 1972, p. 1009). They reduced wool in the presence of formaldehyde and a water-soluble boron compound, which resulted in about 10 per cent shrinkage of the pile yarn and (0·5 per cent) incorporation of a small amount of boron in the yarns.

The untreated wool shag carpet samples (35 oz/sq yd pile weight and 2-inch pile height) were submerged (shag side down) in 500 ml of a solution containing formaldehyde (7·7 per cent), borax (7·7 per cent) and sodium hydrosulphite (1·5 per cent) at 90°C for 20 minutes. The temperature was then raised to 100°C and maintained at that for 20 minutes. The samples were then washed in tap water and in trichloroethylene before drying at 100°C for 2 hours. In another process, a commercial flame-retarding agent (I) was placed in contact with the carpet at room temperature for 8 hours or more followed by heating at 115°C for 40 minutes. In yet another process, another commercial flame-retardant (II) was applied and the carpet dried at 99°–115°C and further heated at 140°–155°C for 4 to 6 minutes.

Among the reducing agents tested, sodium hydrosulphite gave the most consistently good flame-retardancy and the highest (0·5 per cent) boron content. Borax, boric acid, methyl polyborate and zinc borate were used as sources of boron. The first two gave the best results; methyl polyborate was the poorest. The flame-retardancy lasted seven shampooings with a detergent (sodium lauryl detergent). The treatment may also be given to flannel fabric. This caused less shrinkage (only 15–20 per cent) and a 5 per cent weight increase and gave a 0·5 per cent boron content.

V. A. Shenai



Look at the nerves!—that's what two research projects from Bombay suggest. This may help evolve methods for early and correct

THERE are 3·2 million leprosy patients in India today. Besides the fierce social stigma, many of them are destined to suffer from irremediable physical deformities. The disease grows slowly and surreptitiously; by the time a diagnosis is made, the damage has gone too deep to be repaired.

The leprosy bacillus, *Mycobacterium leprae*, was discovered exactly a hundred years ago by Dr. G. Armauer Hansen, a Norwegian physician. But, till today, the bacillus has not been successfully grown in culture nor has it been satisfactorily transmitted to experimental animals. These are the major obstacles in research — in the testing of new drugs, in the preparation of a specific vaccine and in immunological studies.

Why is the diagnosis so belated and sometimes erratic? One reason maybe that by the time the patches on the skin become alarmingly prominent to call for medical assistance, the disease has been on for quite some time. The other reason maybe that wrong tissues are taken for diagnostic tests. This is the finding of two research projects conducted at the Tata Department of Plastic Surgery at the J. J. Group of Hospitals in Bombay.

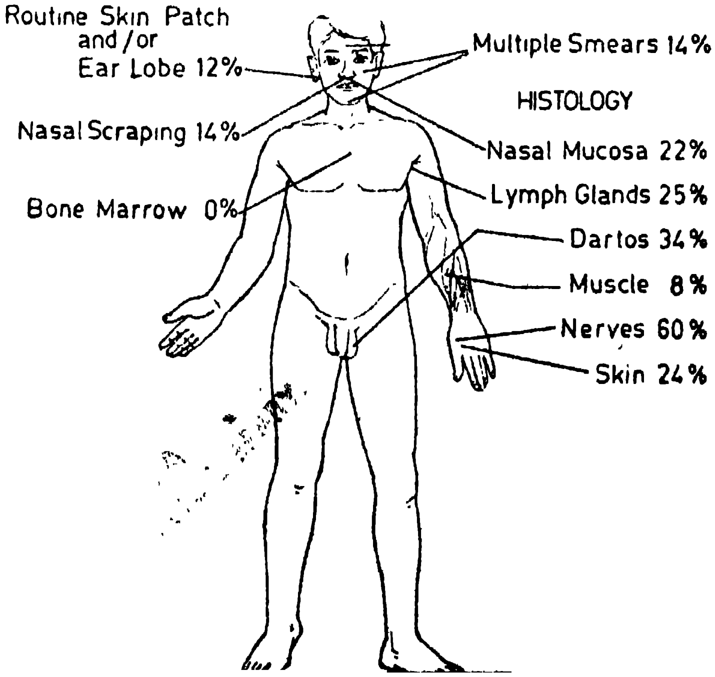
One of these, financed by the Wellcome Trust of England through the Society for Reconstructive Surgery, Rehabilitation and Research (3R Society), was an investigation of various body tissues as reservoirs of leprosy infection in man. The research team — Dr. N. H. Antia, Dr. N. J. Pandya and Miss P. V. Bhatt — studied 50 volunteer leprosy patients (45 males and 5 females) ranging in age from 11 to 51 years. Most of them had taken treatment, some for a few months, others for several years; but there were also a few who had had no treatment at all.

In addition to smears taken by the routine method from skin patches and/or ear lobes, multiple smears were taken from varied sites such as the forehead, cheeks, buttocks, and the inside lining of the nose. These were stained with special dyes and examined for bacilli.

Further, small portions were taken from skin patches, skin of the scrotum and underlying

Fig. 1.

LEPROSY BACILLI OBSERVED IN TISSUES OF 50 LEPROSY PATIENTS



muscle, involved nerves, the inside lining of the nose, lymph glands, and paralysed and unparalysed muscles. These were divided into two equal halves and examined by separate techniques. One half was homogenised, examined for the presence of *M. leprae*, and the total number of bacilli per gram of tissue was calculated. From the other half, sections were cut, stained and examined under the microscope to study the involvement of the tissue in the disease and for the presence of bacilli (qualitative histology).

The results were quite startling. Smears by the routine method showed the presence of the bacilli in only 12 per cent of the patients, with multiple skin smears and scraping of the inner lining of the nose showing a slightly higher incidence (14 per cent).

At the other end of the scale, examination of the nerves revealed that 60 per cent of the patients harboured the bacilli, including some patients who had been on regular treatment for more than 10 years. (The comparative incidences found have been shown in Fig. 1.) The load of bacilli found through the homogenisation technique is given in the attached table; this also shows the heaviest involvement in the nerves.

TABLE I: LOAD OF BACILLI ON HOMOGENISATION

Tissue	Average quantity/gm
Nerve	$8{\cdot}6 \times 10^7$
Lymph Node	$4{\cdot}4 \times 10^7$
Nasal Mucosa	$2\ 0 \times 10^7$
Dartos	$1{\cdot}5 \times 10^7$
Skin	$2{\cdot}85 \times 10^5$
Muscle	$2{\cdot}6 \times 10^5$

The study reveals some interesting facets of the disease which, though suspected, had not till now been conclusively proved. First, the nerve is the most predominant and most heavily involved tissue in leprosy. This also accounts for the deformities seen so often in this disease. Second, while the mere presence of bacilli does not necessarily mean that the individual is infectious, comparative data of this study indicates that the routine method of examining a patient by a smear of skin patch and/or earlobe may be prone to error. The scrotal skin and underlying muscle, not commonly suspected of involvement in leprosy, were found to be quite heavily involved. The lymph glands and the nasal mucosa were also involved in a significant number of cases. On the other hand, the skin, often the focus of attention in leprosy, was found to be a relatively unimportant site of involvement. The study confirms that leprosy is a disease of the nerves rather than of the skin.

THE OTHER project, with Dr. (Mrs.) Lata Mehta, Dr. N. H. Antia, Dr. (Mrs.) P. F. Irani, and Mrs. P. V. Shetty on the team, took on an investigation of the changes in nerves in early cases of leprosy. A very fine branch of the nerve supplying the index finger (index branch of the radial cutaneous nerve) was chosen for the study, for two reasons — it could be biopsied without leaving any major defect in sensation, and its conduction velocity could be easily ascertained by electro-myography.

Accurate methods of testing the sensory modalities of touch, pain and temperature were used to determine the clinical status of the nerve in several volunteers. Based on these tests, 17 subjects were chosen for further study; these consisted of 5 healthy volunteers, 7 leprosy patients in whom this nerve was not involved and 5 patients in whom it was partially involved (as ascertained in clinical tests).

The index branch of the radial cutaneous nerve of these subjects was biopsied and examined by quantitative and qualitative histology and by electron-microscopy.

The results of this study showed that, even in early cases of leprosy where the involvement of the nerve could not be ascertained in clinical tests, electromyographic tests indicated delayed conduction in the nerve; also, definite evidence of involvement was revealed by electron-microscopy. Similarly, in those cases where the nerve was found partially involved in clinical examination, electro-myography and electron-microscopy showed evidence of advanced damage.

These findings provide further proof that leprosy is probably a diffuse peripheral neuropathy even in the early stages of the disease; this could prove useful in volving methods for early detection.

The results of both studies were presented as papers at the 10th International Leprosy Congress held at Bergen, Norway, last month to coincide with the centenary of the discovery of the leprosy bacillus.

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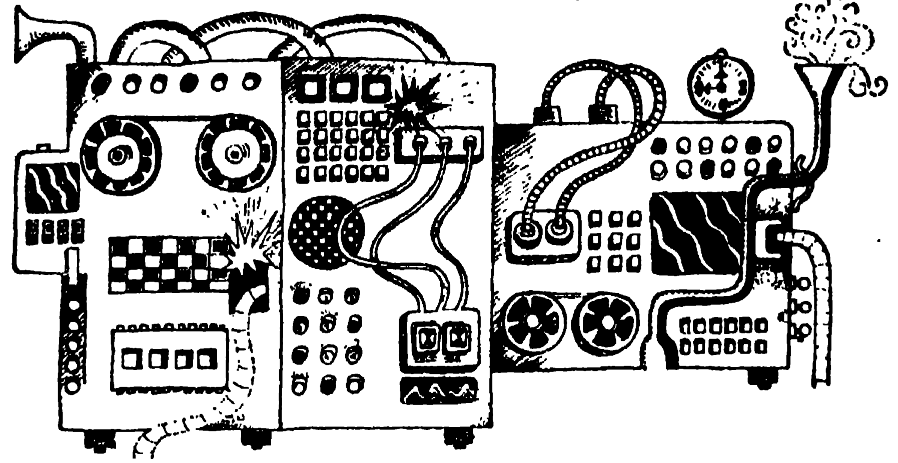

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Advertising pays?

THE admen would say, it does. Arch Woodside of the University of South Carolina College of Business Administration says, it does more: it also shapes a society's parameters of judging its members. In the US *Journal of Applied Psychology*, he has described an experiment he conducted on 157 college students. His conclusion: " People judge other people by the *brand* of a product they consume. "

The product on Woodside's list was beer. He gave each subject a shopping list for a small party and asked them to judge the character of the man throwing the party. The list included either two cases of a well-known brand of beer or two cases of an unidentified brand; some lists did not mention any beer at all. When the character descriptions were studied, it was found 62 per cent of those with the list with the well-known brand judged the party-thrower favourably. Of those who found brand X on their lists, only 29 per cent had a good opinion of the shopper, while 40 per cent gave him a negative score, calling him " unintelligent " or " unimaginative. " In fact, the man who didn't offer any beer did better than the brand X beer-buyer; 38 per cent gave him a " good " score, and 40 per cent a negative score.

Were the evaluations conditioned by the beer-drinking habits of the assessors or by the image crated by advertising campaigns ? Woodside is positive that the personal drinking habits had nothing to do with it — the scores given by both heavy and light drinkers were identical. Advertising creates the mass appeal, and hence the value judgement, he says, and not just for beer — any widely-used consumer product would qualify.

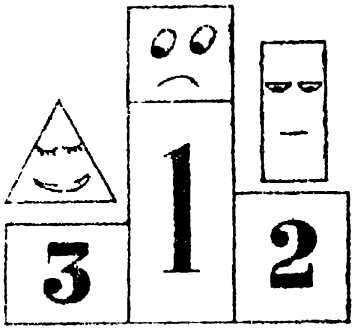
Square is beautiful?

HOW does one measure the aesthetic value of a shape or a form or even music or poetry? Is it just a feeling aroused in an individual's mind or can it be quantified ? According to *New Scientist*, one mathematician, G. D. Birkhoff, tried it with a formula (his book, *Aesthetic Measure*, written in the 1930s, has remained obscure) :

$$M = O/C$$

What are M, O and C ? Birkhoff classifies them thus: C is the attention of the viewer, directly proportional to the complexity of the work; M is the aesthetic measure of the feeling of value or pleasure that comes from the viewing; and O is the subliminal awareness of a harmony or symmetry or anything else that may not be apparent immediately but which is there to complete the effect.

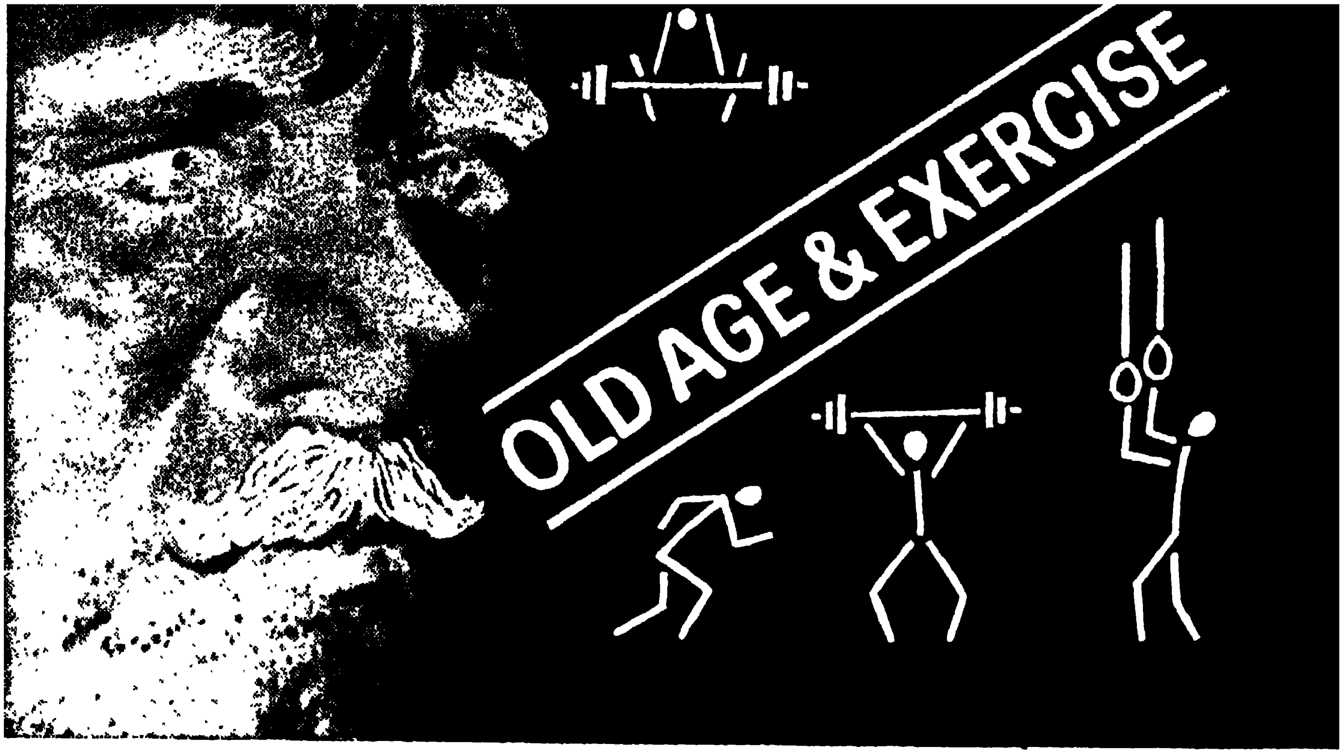
Birkhoff's favourites were geometric forms, particularly polygonal forms. In his aesthetic hierarchy, squares top the list, with a value of 1·50. Next comes the golden rectangle (1·25) and then the equilateral triangle (1·16). The isosceles triangle fares low — 0·63; while the right-angled triangle (with a vertical and a horizontal side) comes out with a zero. A point of interest: Plato thought the right-angled triangle was the most perfect of triangles ! The scalene triangle gets a minus from Birkhoff.



Poor triangles! The defenders, Plato included, consider the triangle to be the simplest and most dynamic form in nature. In art, it represents dynamism, displacement and motion, while the square is a symbol of harmony and stability. The four regular solids representing the four elements can be constructed from triangles : earth — cube, air — octahedron, fire — pyramid, and water — icosahedron. Kandinsky, the world's first abstract painter, wrote in 1910: " ... A triangle has its particular spiritual perfume. " Or, to go back to the 18th Century Japanese Zen Buddhist priest, Sengai, the universe is a picture of a square linked with a circle and a triangle. But the circle, symbolising the infinite, is formless; man, having intellect, needed the tangible form — the triangle. It is the beginning of all forms; even the square is a doubled triangle.

The story-tellers too would agree. It is when the triangle enters the passions of men and women, does the tale become telling.

P.P.



OLD AGE & EXERCISE

MAN was not made to be a runner, they say. His legs are not designed like the gazelle's, nor like the cheetah's. His body is not built to endure like a horse, his ageing is not slowed like the turtle's. Yet men run, leap, endure gruelling demands on their stamina. And some do these better than others; we call them athletes. The peak in these athletic performances is confined to the youth. After that, the body starts taking it easy.

Must the middle-aged and the old remain sedentary by nature ? Is the lack of activity a result of ageing or can ageing be slowed down by exercise? Physiologists agree, most physical faculties slow down after thirty years of age. But a team of researchers at the Perdue University in the United States has come out with some startling statements after they led some 60 sedentary middle-aged faculty-members, through four months of heightened physical activity. They say : A middle-aged man gets more than muscle tone from heavy exercise. He is also likely to become more self-sufficient, resolute, emotionally stable — and imaginative.

Can physical activity really change the state of one's mind? Also, if physical exercise can bring on such changes, it may be possible to create other experiences that can change supposedly crystallised personalities !

Nothing like the Perdue study has been done in India; the middle-aged man has been left alone to his middle-age spread. However, two important studies have been done in two related areas. One, conducted by the Defence Institute of Physiology and Allied Sciences at Delhi Cantonment, studied soldiers, the most homogenised sample of physically active men, between the ages 18-46 years and measured the levels of performance in physical as well as mental tasks. The conclusion : after thirty, all physical abilities decline, while some mental abilities may show a rise for some time.

The other study, conducted by the Netaji Subhas National Institute of Sports, on the state of mind of top-ranking Indian athletes, underlined a strange factor known as psychic readiness which not only determines the quality of their performances but also conditions the height of their goals.

Further, the relationship between aggressive, self-assured dominance and physical activities has been an accepted fact. Is this dominance a result of physical activity or its cause ?

Maybe it will be a long time before these questions can be answered authoritatively. Ageing cannot be reversed, nor can it be slowed down appreciably. Not yet. But as

the Perdue study indicates, certain losses that are taken for granted with advancing age may be lessened or even reversed. Here we present the three studies mentioned above.

How Age Affects the Body and the Mind

M. S. MALHOTRA

BIOLOGICALLY, ageing is a continuous process stretching over the whole life-span. Infancy, childhood, adolescence, youth, middle age, old age — the merging of one stage with the next is slow and imperceptible. There are, however, certain critical age ranges in which important changes in the body start to manifest.

Most of these changes are quite well known. For example, there is greying of hair as well as their loss with age (the loss, though, is more noticeable in men than in women). Reading becomes progressively more difficult. The hearing, particularly for high-pitch sounds, also gets affected.

The muscular power also gets reduced. The connective tissue normally separates various muscle fibres in the muscle and is present in very small quantities in young age. It, however, increases with age resulting in corresponding thinning and decrease in muscle fibres which, in turn, reduce the muscle power progressively. Simultaneously, there are changes in the heart and blood vessels. There is a general narrowing of the arteries all over the body. This results in reduced blood supply to the heart, muscles and other tissues thereby reducing the functional efficiency of all the organs and muscles. Further, reduction in the force of the heart leads to lesser cardiac output per minute as well as the volume of the blood pumped per beat; this affects the capacity for maximal physical work.

Contrary to the popular belief, even height is affected with age. There may be reduction up to even 10 cm compared to maximum height at youth. This is due to flattening of the cartilaginous discs situated in between the vertebrae forming the backbone. Changes in digestion, absorption and utilisation of food result in loss of fat and other nutrients from the body, especially from underneath the skin. This causes wrinkles on the face and the body; the bones too get thinner with age.

What about the brain ? Does the mind age too ? It does, to an extent. As there is no regeneration of cells in the nervous tissue, the brain cells which die with time, do not get replaced. The mental functions which are most directly affected by age are the speed of perception and speed of learning. The first takes its toll on the pace with which various mental tasks are completed; the second on the learning ability.

The old are said to remember long past events in details, but forget happenings of recent past. Some of the old memories may be vivid because they have been revived many times over the years; the decline in recent memory may be attributed to an impairment in the mechanism responsible for either acquisition of new information or its recapitulation.

THE EXACT period of life when the various changes occur differs from individual to individual — the chronological and biological ages in most people are not the same. Some people look younger than their age, some look old before they are. These variations are dependent on many factors like environment, heredity, nutrition, state of physical activity, etc.

Of all these factors, heredity appears to play a most dominant role. For example, onset of greying is much earlier in some families, while in others, it is considerably delayed. Hypertension, coronary heart disease and diabetes, which have a profound influence on ageing, are hereditary. Nutrition undoubtedly plays a prominent role as many of the atrophic changes of old age are attributable to nutritional disturbances or imbalances existing in the system. It has been shown in animal experiments that their life-span can be increased by limiting their caloric-intake and thus retarding the rate of growth. Again, both over- and under-activity have been found to hasten the process of ageing.

WHAT ARE THE critical age ranges during which physical and mental changes start to manifest in Indians? This problem has been studied on about 900 Indian soldiers between 18-46 years of age by the Defence Institute of Physiology and Allied Sciences at Delhi Cantonment. About 98 per cent of the troops come within this age range. The soldiers were selected by random sampling method from among 10,000 troops to make the study as broad-based as possible. To a gerontologist, a military population is a highly reliable and representative model for any study of ageing processes as this population consists of subjects of a highly homogenous nature as regards their nutritional status and daily physical activity.

In this study, the effect of age on physical work capacity was assessed by a number of performance tests in the field as well as controlled physiological tests in the laboratory. The field performance tests were designed to measure agility, abdominal and trunk muscle strength, arm and shoulder muscle strength, time in 100 metres sprint and 3·2 km endurance running with a load of 15 kg. The subjects were highly motivated and, to get their best performance in the field tests, a spirit of competition was created between different units involved in the test. The laboratory tests were meant to assess the maximum capacity for oxygen uptake by the body which is taken as a measure of maximum performance that a person is capable of. The other tests consisted of measuring the time of running at fixed speeds of 9, 11, 13, 15 and 17 km per hour on different occasions till exhaustion comes. Another test was the time taken in endurance-stepping on a 38 cm high stool at the rate of 30 steps per minute till complete exhaustion.

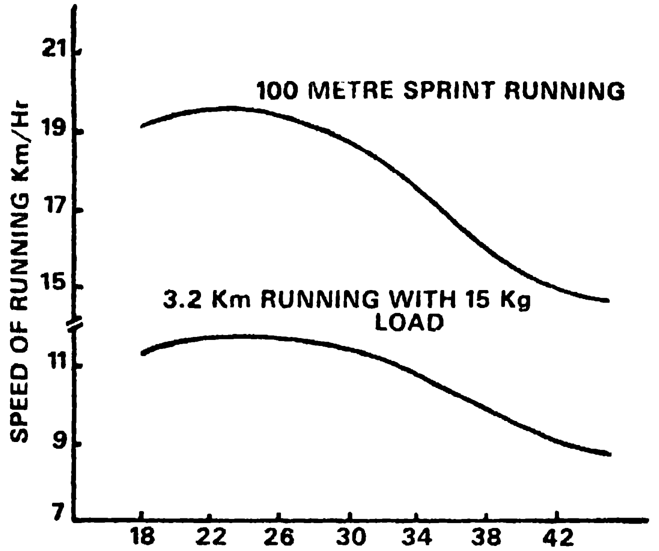


FIG. 1. SPEED IN 100 METRES SPRINT RUNNING AND 3.2 Km RUNNING WITH A LOAD OF 15 Kg AT VARIOUS AGES

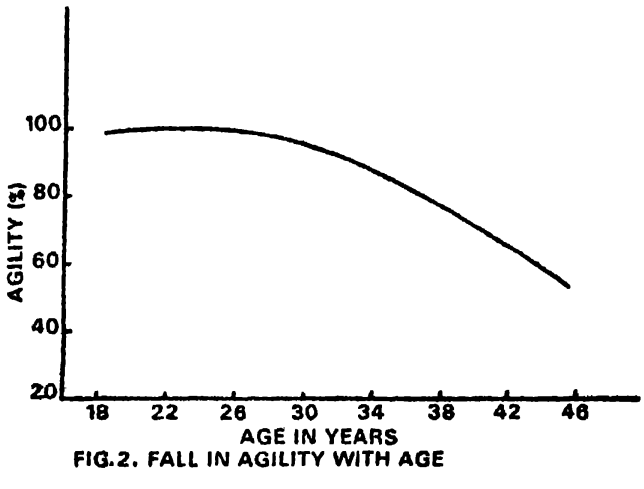


FIG.2. FALL IN AGILITY WITH AGE

The results were very striking. The speed in the 3·2 km run with 15 kg load (Fig. 1) showed a fall after the age of 30 years and a further excessive decrease was observed after about 37 years of age. In sprint running also, the speed reduced gradually after the age of 30 years. The agility of the subjects too showed a progressive decline after 30 years (Fig. 2). The arm and shoulder muscle strengths as well as the abdominal and trunk muscle strengths started to fall between 28 and 30 years and showed a further reduction at 37 years of age.

The field tests thus showed that the ageing process, as it affected the physical capacity, commenced at about 30 years and was further accelerated after 37 years. On the basis of this finding, three age-groups, 18–30 yrs, 31–37 yrs and 38–45 yrs were formed (for statistical comparison of scores in the laboratory tests). The maximum oxygen uptake capacity in the three groups showed a progressive fall from younger to older groups, the mean values for the three age groups being:

(*a*)	18–30 yrs	2·92 lit/min
(*b*)	31–37 yrs	2·69 lit/min
(*c*)	38–45 yrs	2·39 lit/min

The time in endurance running for these three age groups also showed wide variations. For example, while running at a speed of 12 km/hr, the 18–30 age group got exhausted after running for 27 min 54 sec; the 31–37 years group reached exhaustion after 18 min 42 sec, and the 38–45 years group, after 13 minutes only. A similar effect was observed in the endurance-step test, in which the mean maximum performance for age groups 31–37 yrs and 38–45 yrs were 70 per cent and 46 per cent, respectively, taking the performance of the youngest age group to be 100. It is thus apparent that effects of age on performance in almost all the field and laboratory tests for measuring muscular power and physical work capacity manifest at about 30 years of age and continue to drop thereafter. Similar findings have been obtained by workers in other countries and it appears that the ageing process in Indians is not earlier than in people of the western countries.

Brain functions

In the same study, effects of age on mental functions were also studied. Investigations relating to perceptual speed, immediate visual memory, learning speed and numerical ability were conducted. Here, only 500 of the subjects were taken, divided into five distinct age groups — 18-25, 26-30, 31-35, 36-40 and 41-45 years.

Perceptual speed was measured by a cancellation task of 5 minutes' duration and the score was based on the number of correct, wrong and omitted cancellations of groups of four letters of the English alphabet from among others. For immediate memory, the subjects were shown for 3 minutes an assortment of 60 miniature line-drawings of familiar animate and inanimate objects. They were required to recall, immediately after presentation, as many objects as they could in the next 5 minutes. Learning speed was tested through a substitution test in which code values of eight geometrical designs were to be substituted as speedily as possible. The number of correct attempts in 5 minutes gave the score. For measuring numerical ability, a set of 10 arithmetical problems, equal number for addition and subtraction, were given, allotting one minute for each problem. The score depended on the correct answers after making deductions for the errors.

Here, the results were quite different: unlike the physical activity tests, the psychological tests showed both rise and fall in different faculties. The performances of various age groups can be broadly divided into two categories: (*a*) where test scores *increased* with maturity resulting from increasing age, and (*b*) where test scores, after a slight initial increase, decreased with increase in age. The learning speed and the perceptual speed fall under category (*b*), and showed an improvement with a peak performance at 30 years of age and declined thereafter (Fig. 3). After 40 years of age, there was a further significant fall. The improvement in these functions from 18–30 yrs is probably indicative of continuity of maturation process and the deterioration afterwards could be due to ageing. Changes in immediate visual memory and numerical ability with age, were of category (*a*) type. Both these functions showed a continuous rise till 35 years of age and thereafter remained steady at this level till 45 years (Fig. 3). This shows that these two functions are not adversely affected with age and reach the maturity level by 35 years, as, by then, optimum amount of experience and skill are achieved. Additional experience does not considerably contribute to their increase and further improvement in these functions does not occur.

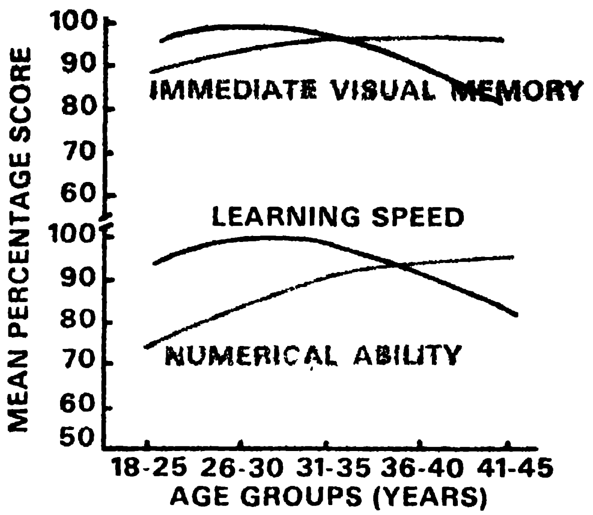


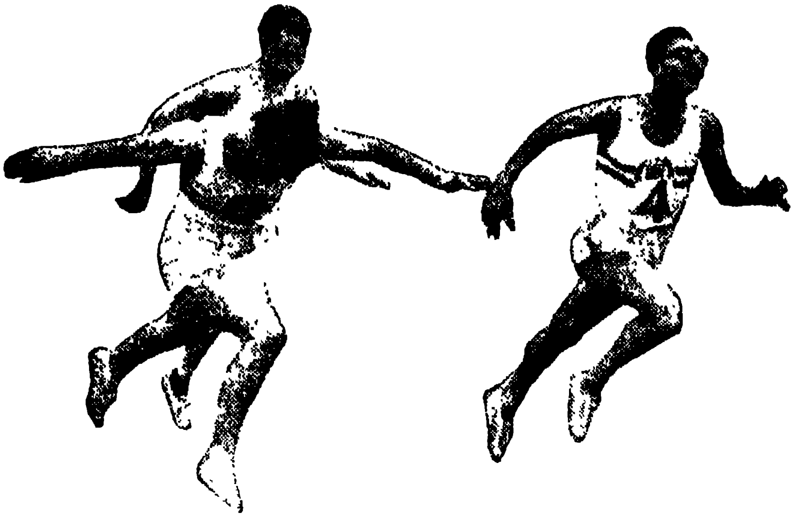
FIG. 3. MEAN PERCENTAGE SCORES IN PERCEPTUAL SPEED AND LEARNING SPEED AS WELL AS IN IMMEDIATE VISUAL MEMORY AND NUMERICAL ABILITY IN DIFFERENT AGE GROUPS

How far these variations of physical and mental functions with age affect the industrial production remains to be assessed. In most industries, the nature work is not as strenuous as the tests used in the study. Maximal work capacity may fall with age, yet the experience and skill gained with age could offset the affect of the age some extent. The overall performance, however, would depend on the nature and type of work.

The fall in physical efficiency after 30 years of age is, however, very important in selecting athletes and sportsmen. It is desirable that for successful performance, they should be picked up at a young age and trained extensively before the slow decline in their physical efficiency starts to manifest.

Surgeon-Captain Malhotra (IN) is Director of the Defence Institute of Physiology and Allied Sciences, New Delhi.

The Mind of the Body-fit



Psychological evaluation of top-ranking Indian athletes

R. L. ANAND
D. N. MATHUR

IN a sports event, it is very difficult to define the psychological and physical variables. The physical education report in this regard has been very controversial. Nevertheless, it has been suggested that persons of high motor proficiency are usually calm, popular and resourceful, while those of low motor proficiency are shy and tense. This is more commonly observed in participants in individual events, such as weight-lifting and wrestling. It is a well-known fact that champion athletes are better able to express powerful emotions, are free from inhibitions, and have high intellectual aspirations and high degree of self-assurance.

While many research studies have been undertaken to explore the physiological responses to physical exercises, relatively few have been directed towards those emotions which commonly precede competitive sports contests. A few years back, the Netaji Subhas National Institute of Sports conducted a study on Indian athletes preparing for the Olympic Games. The basis of the study was what is commonly known as 'psychic readiness' for competitive sports. This is an adaptation condition without which the athlete is open to instability and there may even be loss of self-control. The subjects were 17 participants in an individual sport, i e athletics.

The investigation consisted in seeking answers from respondents through personal interviews to questions based on a questionnaire supplied by the International Committee on Olympic Medical Archives. The questions were framed to investigate the general psychological preparations of the athlete during important athletic activities, under eight heads: 1. level of self-assessment; 2. emotional balance; 3. concentration of attention while performing motor activities; 4. effect of warming-up on mental stability; 5. satisfaction; 6. aggression; 7. frustration; and 8. reaction to injury.

As regards self-assessment, four throwers and two triple-jumpers felt they would be able to improve their performance. However, eight long-distance runners were not sure about the outcome of their performance. Physiologically, triple jump and throwing events are included in the strength-requiring events and long-distance running in the endurance-requiring events. It appears athletes having more strength have more self-confidence. However, all the athletes agreed that even if they had all the favourable conditions in competition including a favourable public opinion, they did not expect a remarkable improvement in their performance at the Olympic Games.

An athlete constantly goes through serious emotional stress all along his active years, though this stress tends to reduce with age and experience. There are vast differences between people as to the intensity of stress that they can tolerate before their physical activity deteriorates in performance. Most athletes immediately assess the intensity and duration of the forthcoming event. Most of our athletes indicated that they suffered from increasing anxiety. Broadly speaking, we obtained two types of answers:

(*a*) Athletes with the experience of five or more international competitions did not feel much of the emotional set-backs like nervousness just before the start of the event. These athletes mainly belonged to long-distance running category.

(*b*) Athletes belonging to short-duration events and who were also immature in terms of experience, e g sprinters and throwers, were found to have emotional instability. Two immature athletes stated that their sleep was always disturbed because of emotional imbalance on the nights preceding the events. They also said all their tension, nervousness and emotional imbalance disappear just after the completion of the event.

WHEN IT CAME to concentration of attention, the throwers and jumpers said they needed two actual throws or jumps before they could concentrate fully. This is undesirable. In most cases, training of our athletes is confined to the performance only though experimental evidences indicate that regular training in sports should also include training for concentration of attention for the performance right from the beginning. However, certain investigators have concluded that once established, individual stability of concentration may not be reduced as it may affect the performance negatively. It was also found that, warming-up has a sizeable effect on mental stability. Physiologically, it prepares the cardio-respiratory and muscular systems to undertake stressful activities. Psychologically, it builds-up mental stability.

Psychologists admit that the extent to which satisfaction affects behaviour cannot be experimentally demonstrated. It is usually regarded as a fulfilment of a need or a goal. Yet, satisfaction may be derived from physical activities even in the absence of goal attainment, e g if one wants to represent one's country in a big international competition, satisfaction will result when this need is fulfilled. However, scientists believe that satisfaction is directly related to the degree of success achieved. In our study, a majority of our athletes said they were happy most of the time. But they attributed this state of mind to an easy-going life. Only 3 athletes out of 17 were not satisfied with their achievements and were mainly of an aggressive nature.

AGGRESSION IS related to anxiety. Psychologists have introduced a term 'pseudo-hate' which may be closely related to aggression in a few cases. There are instances of 'pseudo-hate' goading an athlete to prepare himself in order to do well. Pseudo-hate is more common between two athletes engaged in neck-to-neck competition. Amongst our athletes, we came across one triple jumper, one marathon runner and one thrower who never liked the superior performance of their close competitors. Their main object was to immediately defeat their close rivals rather than doing something more.

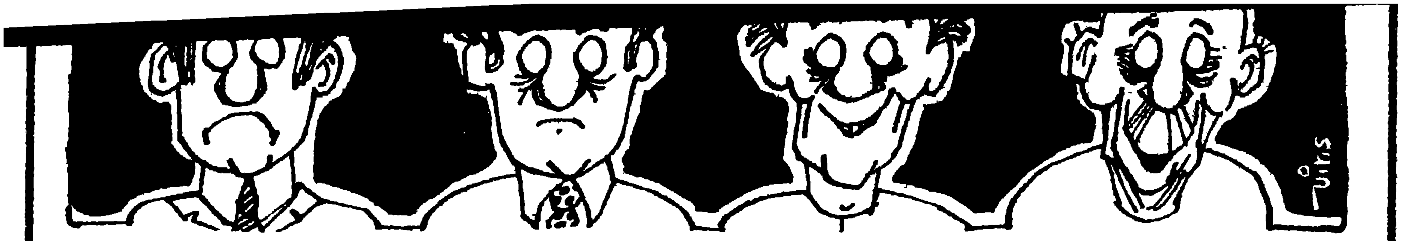
On the other side of the prize trophy is frustration. It may lead to worry, fear, anger and anxiety. Reward, however, may reduce frustration. Most authorities believe that aggression is an ultimate response to some frustration. Fortunately, none of our athletes showed any signs or symptoms of frustration.

How did they react to injury? The athletic competitor who needs to win, and whose aim is primarily achieved through physical activity, may react to injury in several ways. He may disregard his injury, hide it from others and go on with the event to demonstrate his special abilities. In other cases, the injury sustained during training or the competition period may be used as a form of psychological shield to explain the poor performance. In either case, the individual tries to maintain or enhance his self-image. We came across two such athletes. However, even with those so-called injuries, they continued to perform well and even bettered their own records.

What conclusions did we draw from this study ? We noticed that hardly any top-ranking Indian athlete was trained psychologically during routine training sessions. Results of international competitions indicate that our athletes are more or less correct in self-assessment, but less ambitious in regard to better results in international competitions. They lack in emotional balance and concentration of attention during competitions. Basically, the top-rank athletes are satisfied and try to remain happy most of the time. They are less aggressive and are not frustrated.

Mr. Anand is Director of the Netaji Subhash National Institute of Sports at Patiala.

Dr. Mathur is the sports medicine specialist at the Institute.



IN SEARCH OF THE ELIXIR!

IF ONLY decay and death could be put off by a few years! When hormones were first discovered it was thought that hormones would do the trick. Many people went in for "monkey gland" treatment. It is only in recent years that systematic work in gerontology has been done, but it is much too early to hold out any hopes.

A number of degenerative changes occur in the body as we age, but their causes are ill-understood. (See "Biology of Ageing", SCIENCE TODAY, January 1970.) Hair whitens (this is said to be due to the accumulation of holes in the texture); there is a 15 per cent reduction in the weight/volume ratio of the skeleton, and, after 35 years, 100,000 brain cells die every day and are not replaced. The skin becomes wrinkled.

The wear-and-tear theory attributes biological ageing to repeated stresses, each illness or stress leaving permanent defects which pile up until some vital organ fails. External factors like the natural background radiation have also been invoked to explain senescence.

The effects of diet and temperature on ageing have been studied by some investigators. Rats kept for about 800 days on a balanced but restricted diet were found to live about 200 days longer than the normal diet rats, but these results don't seem to apply to humans. Animals in general live longer at lower body temperatures.

MAYBE there is a "youth factor" involved, say other researchers who hooked up animals in pairs, one old and one young (in Siamese-twin fashion) so that they shared a common circulation. In such pairs, the older member lived longer than normal.

But the secret of ageing perhaps lies in the individual cell. Is the life-span of the cell related to that of the individual? At any given moment, some cells are dying and new cells coming into existence by the binary fission of older cells. In a famous experiment, Nobel Laureate Dr. Alexis Carrell kept alive for 20 years a piece of chick embryo heart tissue by maintaining it on nutrient broths. Normally, however, a cell has a finite life. Leonard Hayflick of Stanford University School of Medicine found that cells divide about 50 times. Cells from persons aged below 20 divided 30 ± 10 times, those from older persons divided 20 ± 10 times, showing a diminishing power of doubling as we grow older, which is finally lost altogether. Of course, it has not yet been established that cells in the body behave in the same way as cells in laboratory cultures, but it is a known fact that several organs lose weight as we grow older.

HAYFLICK AS WELL as other researchers suggest that as an organism ages, cell division proceeds with less efficiency and accuracy. With every succeeding cell division, more and more errors are introduced in the self-copying mechanism, and almost any error, if it involved a vital enzyme, could result in a chain-reaction which would ultimately clog the manufacture of proteins in the cell. In fact, the longer life span of man, as compared to most animals, may be due to a more efficient mechanism for such copying.

Of course, it is possible that there are selection mechanisms that weed out enzymes which lead to too many errors — by a segregation of their products — but none such have been observed. Some experiments seem to lend support to the defective protein synthesis theory, eg, the fungus Aspergillus grows steadily at a constant rate; then there is a sudden drop in growth, accompanied by the production of a brown pigment, swelling and bursting of the advancing hyphae (filaments) and finally death. These phenomena, researchers hypothesise, mean that the growth of the hyphae is linear, while the increase in errors is exponential and beyond a point, catastrophe cannot be prevented by a linear growth. Also, it is known that amino-acid analogues (ie, chemicals that are not quite like the amino-acids) induce errors in protein synthesis, and when these analogues are introduced into cultures, they reduce their longevity.

Dr. Alex Comfort, the leading gerontologist, thinks that free radicals in the cell could cause ageing. A free radical (a group of atoms normally found in combination with other atoms but capable of independent existence) will combine "with anything that's around", disrupting the information content of important molecules.

YET OTHERS BELIEVE in a "death hormone" which, released by the brain at critical times of life, could prevent body cells from utilising other hormones (possibly the thyroid hormone).

The rare disease called progeria could possibly provide insights into the ageing process. In this disease, ageing is greatly speeded up, a child shows signs of senility at the age of two, finally dying as an "old man" at 12 years or so. Cells taken from such persons divide only a few times.

In fact, many gerontologists believe that the ageing process is programmed into the cell, just like the other information needed for its vital activities, so that senility is itself a disease, and even if we succeeded in warding off other killers like cancer, coronary thrombosis and tuberculosis, we would still be faced by the failure of the cell to divide.

P. K.

AT the Perdue University's Field House track, the sight of 60 middle-aged running men would have provoked a forgiving smile from a casual onlooker. But there was nothing pitiable about them: they were part of an important study to find out if exercise brings on any physical and mental changes in middle or old age. (The study was reported in a recent issue of *Psychology Today*.)

The subjects were all members of the staff and faculty of the University, and almost all of them lived sedentary lives with desk jobs and all were " unfits " by any physical fitness standards. The investigators, Professors H. A. Ismail and Robert Young, had two objectives in bringing these people to the tracks: one, to find out if the body showed changes after four months of exercise; two — and this was the participant's main motivation — to help men " gone-to-pot " get back onto the swing of health.

The physical check-ups showed remarkable improvements. Study of fat and muscle tissues, blood pressure, heart-jump rate and metabolic factors showed marked enhancement in all subjects. In some cases, hearing and vision also improved.

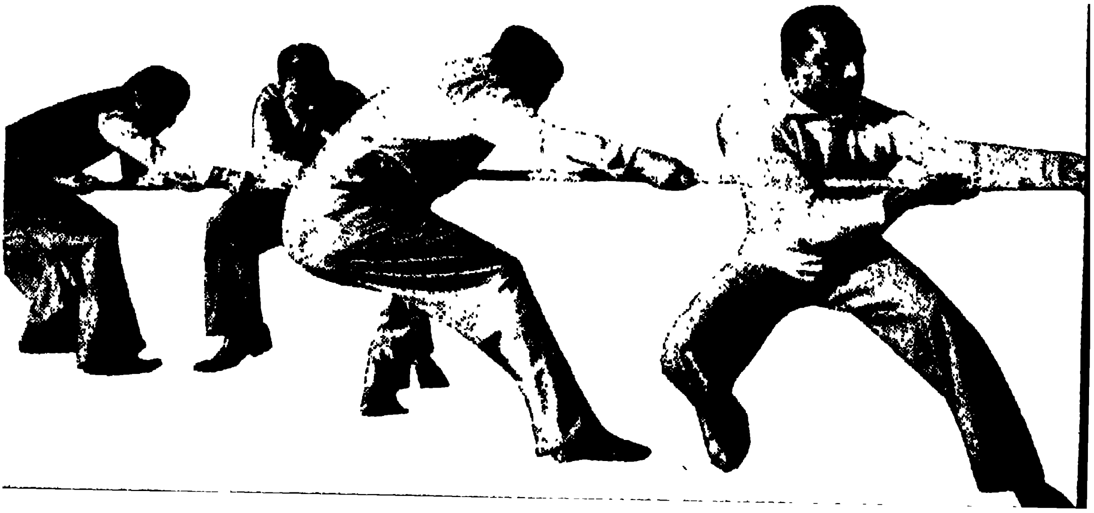
But, more startlingly, besides the physiological changes, the personalities of the subjects were changing too. At the start of the programme, hypochondriacal complaints (like " pre-heart " attack !) were pretty common; by the end, these had almost disappeared. The men also seemed to have become more open and extraverted. They also appeared to be more stable and self-confident.

A problem arises when one looks for parameters of psychological evaluation of these personality changes. Most published reports deal with athletic stereotypes and label them as competitive, insensitive, brutal, fair, sportsman-like, masculine, arrogant, genteel or immature — depending on who is the assessor. After a long search, Prof. Ismail chose Raymond Catell's 16 Personality Factor Test. This test evaluates 16 major personality factors in a person, rating each on a 10-point scale. "High" is a score above six; "low", a score below four. Catell assigned dual adjectives — bipolar ones — to each factor; for instance, if Q 2 showed a low score, it would mean not just absence of self-sufficiency, but *presence* of group dependency.

Factor	A	reserved	outgoing
Factor	B	less intelligent	more intelligent
Factor	C	affected by feelings	emotionally sta
Factor	E	submissive	dominant
Factor	F	serious	happy-go-lucky
Factor	G	expedient	conscientious
Factor	H	timid	venturesome
Factor	I	tough-minded	sensitive
Factor	L	trusting	suspicious
Factor	M	practical	imaginative
Factor	N	forthright	shrewd
Factor	O	self-assured	guilt prone
Factor	Q_1	conservative	experimenting
Factor	Q_2	group dependent	self-sufficient
Factor	Q_3	uncontrolled	controlled
Factor	Q_4	relaxed	tense

Ismail gave this test to the participants before the start of the programme and again four months later. In the beginning, the group

I Am Over Forty. So What?



Science Today October 1973

jogged for 10 minutes to warm up, then had group exercise for 30 minutes. The emphasis, of course, was on supervised running. At the start, few men could run more than half-a-kilometre; at the end of the programme, most averaged 3·5 to 5 km (some did even 8 km). The run was followed by games or swimming. It was remarkable, since even unpractised 20-year-olds would find this extremely difficult.

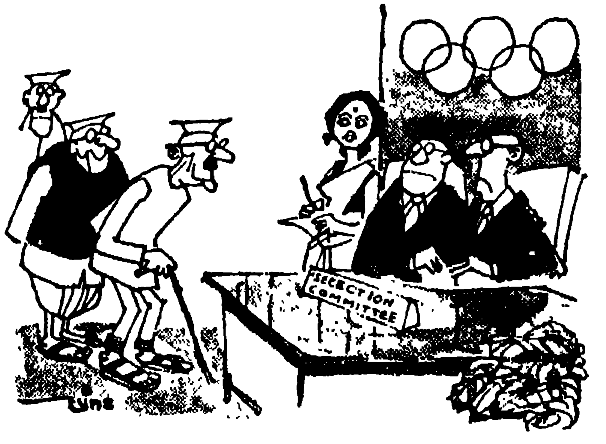
CAUSE OR EFFECT?

Two American researchers, A. C. Werner and E. G. Cottheil, had given the Cattel 16 Personality Factors Test to US West Point military academy cadets and found athletic types were more sociable, dominant, adventuresome and group-dependent than non-athletes.

A few years ago, Thomas K. Cureton and William Heusner applied the same test on Olympic champions who were found to be more intelligent, more emotionally stable, more venturesome and much more self-assured than others. They also "tended to disregard rules and reject group standards".

This raises a snag. Some researchers interpret this data to mean that the personality of the athlete is a direct effect of his physical conditions, which in turn is an *effect* of his participation in athletics. Others, see the difference in personality as a *cause;* the personality factor, they say, is inborn and it is this which enables the athlete to survive the ruthless selection and competition in sports. If you are not born with it, you don't go into sports ; or, if you do, you soon drop out.

That is the question! Are sportsmen dominant because of participation in sports, or are they sportsmen because they are born to compete and be dominant? The answer is yet to be found!



"Prime Ministers and Presidents for Olympics? It figures! If athletes are dominant, then the dominant must be athletic!"

THE PERSONALITY changes were clearly visible. The initial fear of heart-attacks subsided and several turned into "mildly sadistic types and took great pleasure in defeating others in foot races, or in spiking a volleyball through an opponent's guard". Confidence too showed an overall rise. Another interesting observation: the subjects showed a third *masochistic* stage — instead of beating others, a man would drive himself hard to better his own performance!

The changes, however, could not be lumped together. The subjects had varying degrees of fitness, eg, some were partially active before the test; others were totally sedentary. Which personality change was a result of exercise and which merely due to *participating* in a group event? The researchers divided the group into two sub-groups of high-fitness and low fitness through physical and metabolic measurements.

The scores on four of these personality factors — M, Q2, C and O — are significant:

Factor	*High-fitness*		*Low-fitness*	
	before	after	before	after
C	6·4	6·1	4·6	5·4
M	7·3	7·2	5·3	6·1
O	4·2	4·1	5·4	6·1
Q_2	6·5	6·6	6·4	8·0

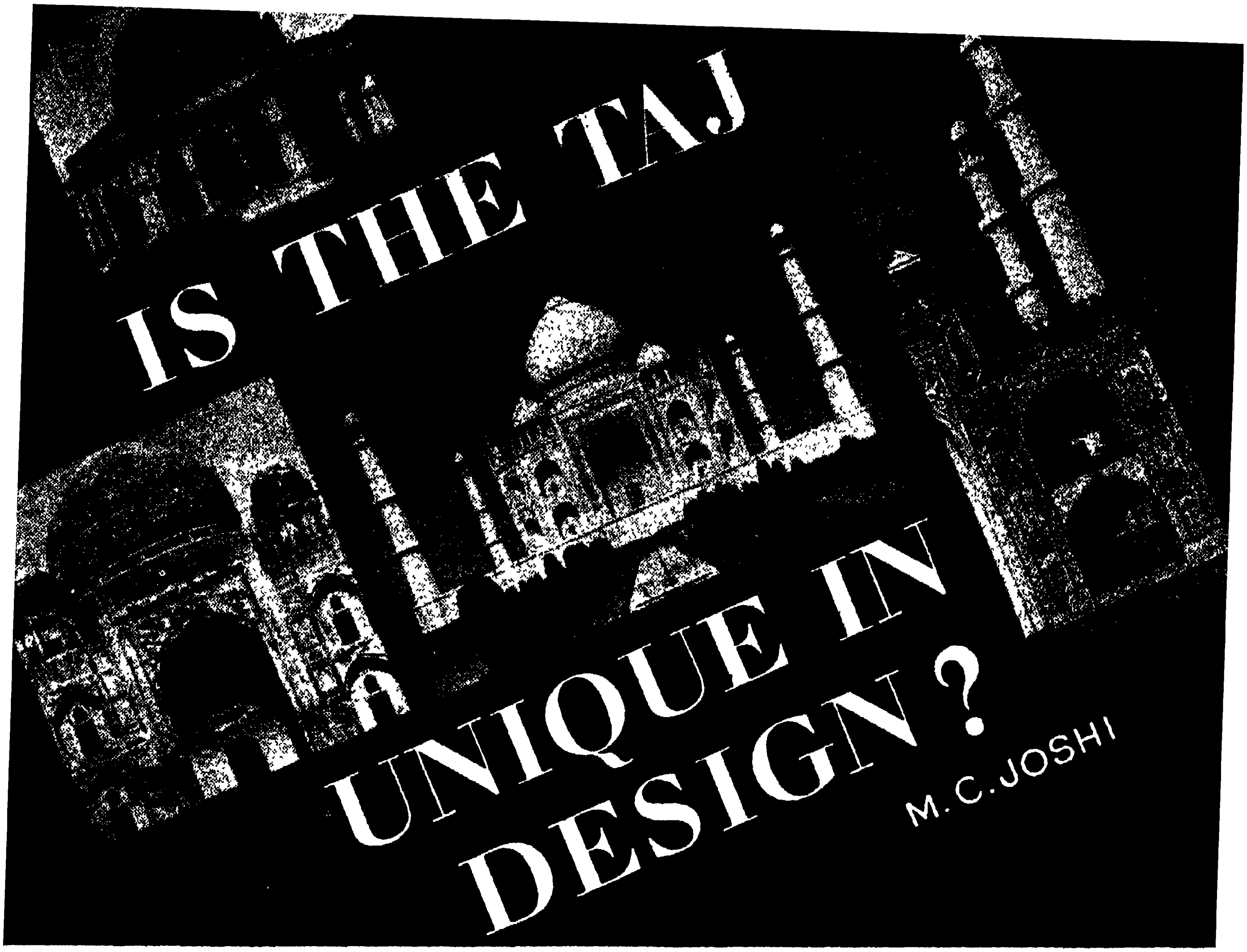
While the high-fitness group did not show much change, the low-fitness group recorded spectacular jumps. One puzzling point is the high value for O or guilt-proneness. The sense of guilt is explained by the researchers as either due to failures in an achievement — oriented world or due to slackening on other routine activities from which they had to take time off to attend the programme.

What had caused the personality changes? Two theories are probable: one is physiolocal — the exercise brings on biochemical changes such as increased circulation to the brain thus providing more glucose essential for the brain's nourishment. The other is psychological — personality changes because a man faces a difficult challenge and overcomes it. Both theories may be partly true, or both may be interacting.

That physical exercise can change the state of one's mind is already established. But Prof. Ismail raises an interesting point: if a tangible thing like exercise can bring on such distinct changes in the minds of middle-aged men, then will it be possible to induce other experiences which may change supposedly crystalised personalities? **P.P.**

IS THE TAJ UNIQUE IN DESIGN?

M.C. JOSHI



On the left-hand top of the collage above is the Sabz-Burj in Delhi. Below it are the Tomb of Khan-i-Khanan in Delhi (left), the Taj (centre) and the minarets on the gate of the Akbar's tomb in Sikandara in Agra (right). Note the similarities in structural forms

THE Taj Mahal at Agra marks the "perfect moment" in the evolution of the Indo-Islamic architecture. Behind it is the crystallised experience of more than a century, relating to the art of construction. What are the architectural features of the Taj ? What gives it such a stunning effect ? What are the threats it now faces ?

The salient features of this mausoleum are the broad and superb conception, pure and soft outlines and luxurious execution, which make it an unparalleled creation of beauty and splendour. Its monumental volume with sensitive and lustrous texture develops an extraordinary charm in the pleasant surroundings.

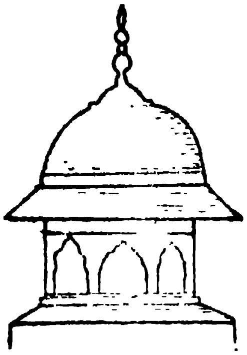
Formality, symmetry and sophisticated manipulation — these are the essentials of the Taj architecture. The keynote of the general layout of the complex lies in the formal garden within the inner court with a central tank and canals. The scheme of the garden itself has been derived from the Persian horticultural plan, called the *char-bagh* or the four-fold plot. This was introduced in India by Babur (AD 1526–30). The *char-bagh* represents the Islamic concept of the garden retreat of paradise. And its association with the Taj is justified, for, wasn't the Taj conceived as a heavenly abode of eternal rest ?

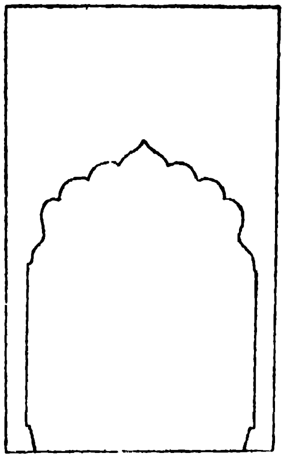
In plan, the garden consists of four main parterres or flower plots formed by means of four shallow canals, all radiating from a central tank like the arms of a cross. Flagged footpaths further divide each parterre into four smaller squares.

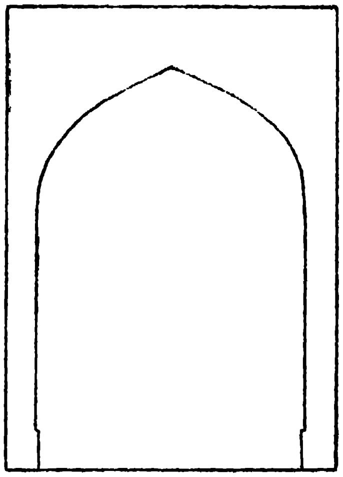
Unlike the earlier Mughal tombs which have been raised in the centre of the garden, the Taj Mahal occupies its northern extremity, opposite the main entrance. Recent discoveries have shown that all the four canals of the Taj were originally studded with fountains, and the garden beds were at a lower level than at present. Traces of pipelines and fountain-stubs unearthed recently seem to indicate the original set-up as it was during the time of Shah Jahan; the arrangement of fountains conforms with the general layout and alignments of the Taj.

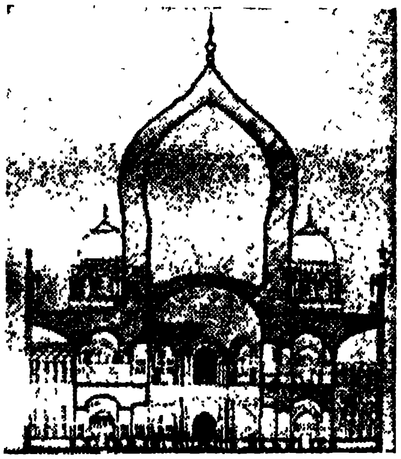
The Taj exemplifies the classical phase of the Mughal architectural style. Its immense scheme shows a harmonious blend of an ornamental garden and structural beauty. Probably, it was the departure from the traditional plan of centrally situated tombs that made this blend successful. The elevated mass of the main fabric with logically disposed ancillary edifices and unbounded space around as backdrop give it a picturesque form. And though the well-demarcated enclosure with high battlemented walls isolates the Taj from its surroundings, it also stresses the structural discipline and the dignity of the monument. In general, the sepulchral complex reflects the habits, manners and the discipline of the imperial court of Shah Jahan, and also his aesthetic taste.

The Taj also marks the culmination of the Mughal building art. Persian elements like the *char-bagh*, irregular octagonal (*musamman-i-Baghdadi*) plan, half-domes (*nim-gumbad*), grand-apses and alcoves predominate in its scheme, but the general structural idiom is essentially Indian, i e Mughal, for it is a logical development of the Akbari style. The Persian or Central Asian traits of the Taj are, therefore, a derivation from the buildings raised by Akbar and not a direct borrowing from Iran or Central Asia. In some of its structural features, e g *chhatris* (kiosks with wide projecting eaves around and cupola) and *guldastas* (flower-topped pinnacles) around the dome, however, there is an impress of the edifices of the Sayyid-Lodi period (AD 1444–1526).


Chhatri


Engrailed arch


Tudor arch

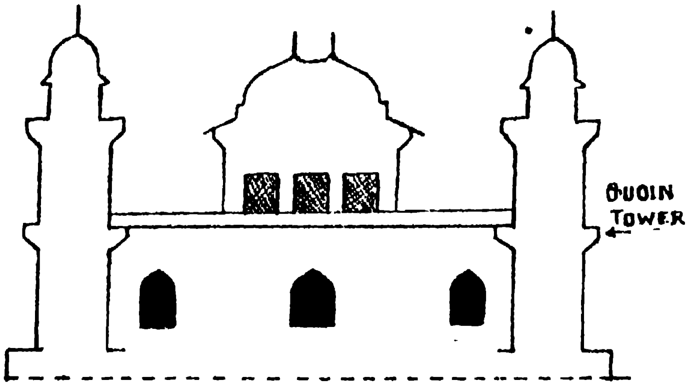

Double dome

THE ORIGIN OF the design of the Taj proper seems to lie in the Sabz-Burj (AD 1530–40) in Delhi. From there, the structural tradition appears to have evolved through the tomb of Humayun (AD 1565–66) and that of Abdu'r Rahim Khan-i-Khanan (AD 1627) both in Delhi. Let us trace this evolution. On the basis of its style, the Sabz-Burj can be dated to AD 1530–40 (*Puratattva,* "Bulletin of the Indian Archaeological Society", Vol. 6, p. 87, 1972). It is the earliest example of the Mughal tomb, and shows an irregular octagonal plan, with four large entrance-arches and a double dome. It has no pre-Mughal features such as *chhatris* or *guldastas*. Then followed the Humayun's tomb, where the irregular octagonal design and the system of double-doming were improved and *chhatris* and *guldastas* added to stress the elevation of the structure. A high basement with a crypt (an underground mortuary) inside was also introduced. Except the irregular octagonal design, most of these features are shared by the mausoleum of Abdu'r Rahim Khan-i-Khanan. On plan, it is a square comprising a central octagonal chamber with a room at the corner and an entrance vestibule amid each side. The Taj was the culmination.

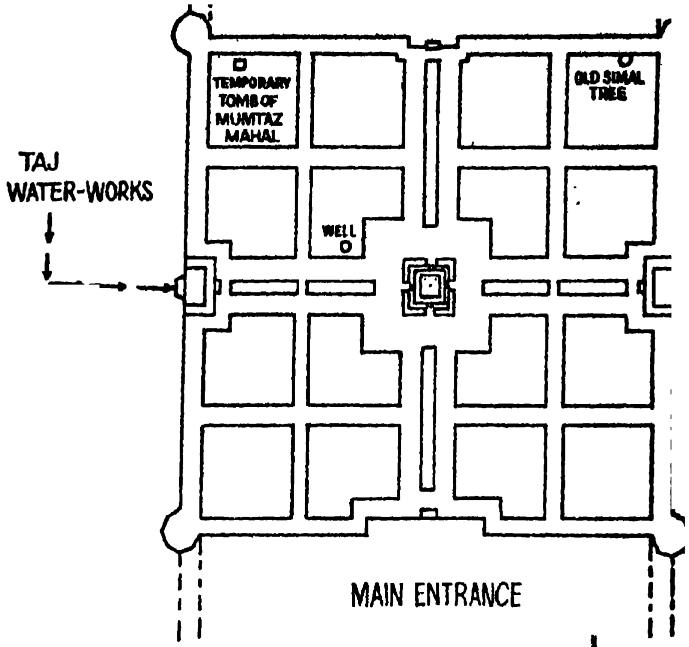
The architectural form of the principal portal, however, seems to combine the square structures common to the Sayyid and Lodi periods and the monumental Mughal gates like the Dihli Darwaza in the Agra Fort and the Baland Darwaza at Fatehpur Sikri. The basic pattern of the attached mosque and the Mihmankhana can be traced to the Qila-i-Kuhna Masjid (Delhi), believed to have been built by Sher Shah Sur (AD 1541). The design of the towers rising along the enclosure-wall might have been derived from the Sher Mandal (16th century) inside the Purana Qila in Delhi.

In the subsidiary sepulchres within the entrance quadrangle, and to the east of it, one can see the adaptation of the octagonal tomb of the Sayyid-Lodi type with an encircling verandah. However, the domed octagonal mausoleum with alcoves on the sides outside the compound on the west is a modified form of the pure Mughal sepulchre of which the Sabz-Burj is an early specimen in India.

Quoin tower (Tomb of I'timadu'd Daula)



The crowning octagonal *chhatris* or kiosks common to the Lodi and the Sur monuments are of Indian origin. Persian and Central Asian structural traditions can be traced in the irregular octagonal plan and the lofty domes on the main building as well as the other buildings of the complex. But their bulbous form constricted at the neck with high drums is purely a Shahjahani development. The idea of soaring minars flanking the main structure stems from the minars surmounting the principal portal of Akbar's tomb, the quoin-towers of the mausoleum of I'timadu'd Daula and the corner minars of Jahangir's tomb, besides kiosks over



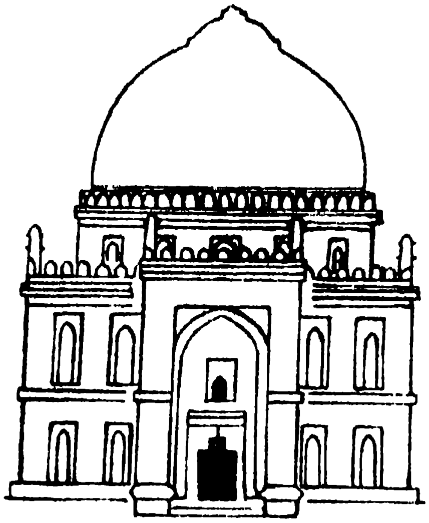
Sketch of the Taj gardens

The Taj

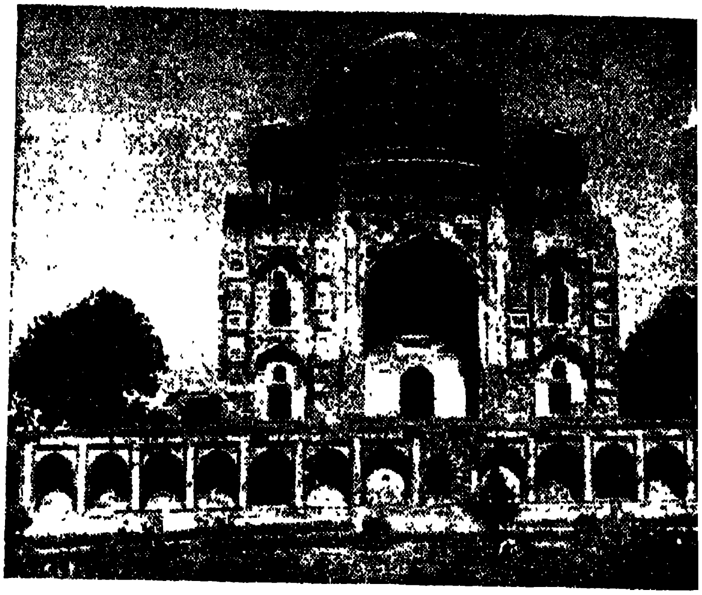
A DOMED structure, the Taj is an irregular octagon in shape (with four long and four short sides) rising above a basement which itself rests on a great platform or a terrace. A graceful minaret stands at each corner of the basement. Besides the great dome, there are four shapely *chhatris* on the top. Apses and alcoves (recesses) mark the marble facade which is formally inlaid with colourful precious stones in exquisitely ornamental forms. High battlemented walls around (562·36 metres × 302·97 metres) with the Yamuna at the back project its distinct personality. The dome over the main structure is said to weigh about 12,192·56 metric tons!

It took over 18 years to complete the Taj. Construction started in AD 1631. The main tomb was built by 1639 and the central portion including the main entrance by 1648. Subsidiary structures within and outside were completed later. According to Tavernier, a French traveller, who claims to have seen the beginning and the completion of the Taj construction, the operations were not finally over until AD 1653. Though some claim that the principal architect was Ustad Isa, a Turk or Persian, recent researches show that the designer was Ustad Ahmad Lahuri, a celebrated building expert of Shah Jahan's court.

Of the two sets of the graves at the Taj, the upper set is false (cenotaphs); the lower set in the crypt (underground mortuary) is believed to be the actual one. It was a common Mughal practice to build false tombs in the upper storeys to indicate the exact burial spot down below, so that none should profane the sanctity of the tomb by walking over it or otherwise.



Bara Gumbad, New Delhi



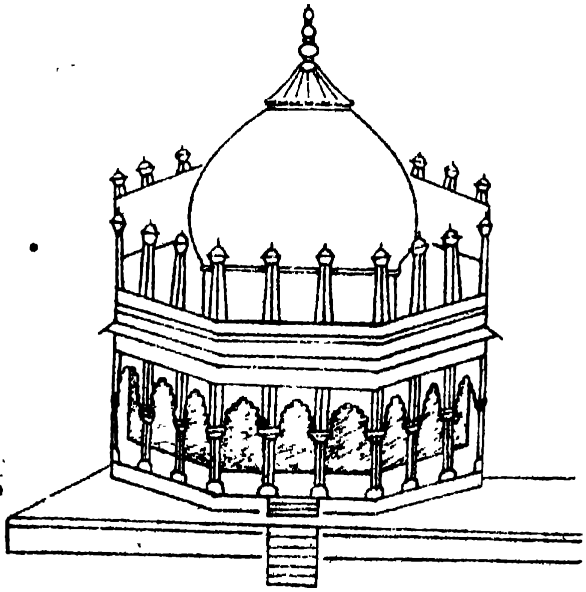
Tomb of Khan-i-Khanan

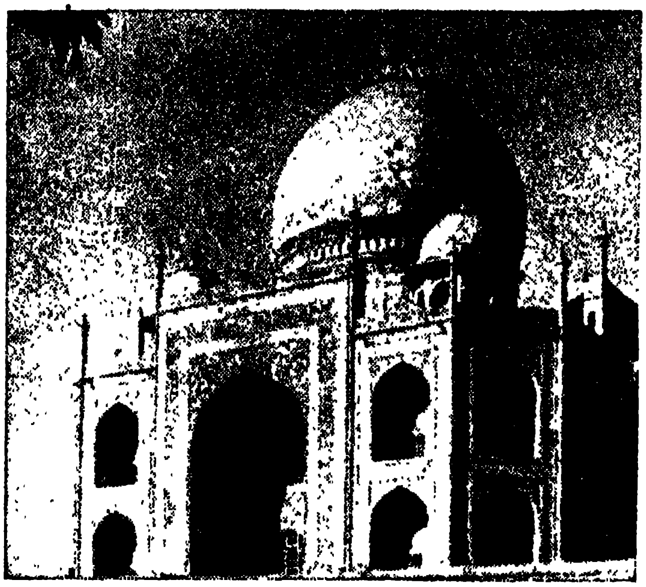
the basement-angles of some of the structures of Jahangir's period or of earlier dates. The minars add grace to the Taj by extending its structural effect.

SO MUCH FOR the form. What is the technique of construction used? Primarily the technique is arcuate, yet the trabeate system (employment of beam/lintel) has been used in the verandahs, cloisters and kiosks. The Tudor type arch too has been used extensively, besides Shah Jahan's favourite engrailed variety. The latter type, however, is purely decorative, and appears in the *chhatris* and some secondary buildings. To give the desired elevation to the structure, matching with the horizontal proportions, the architects have provided either crowning *chhatris* or followed the system of double-doming. And it is this emphasised elevation with two domes which necessitated the use of the irregular octagonal superstructure with the grand apses and arched recesses. The frequency of *guldastas* outside also stresses the vertical form of the structures. Multiple alcoves (an alcove, being a deep arcuate recess or niche, also functions as an arch in distributing the weight, supporting the superstructure and binding it together) within and outside the buildings have been used not only for structural strength but also for breaking the monotony of the facade. For structural firmness and beauty, mostly the quoins of the buildings within the complex have either been bevelled or turned into octagonal towers.

The monument also stands testimony to the technical skill and scientific thought of its builders. This is evident from the excellent handling of material and the perfect use of the constructional devices — the accurate technique used in raising the grand dome and distributing its heavy weight evenly, the method of laying the foundation, and the subtle manipulation of the minute details in structure, inlay, sculpture and painting. The whole complex is so planned that the apparent organic unity of the complex does not obscure the individuality of any unit. Nor does it

Octagonal tomb in the entrance quadrangle of the Taj



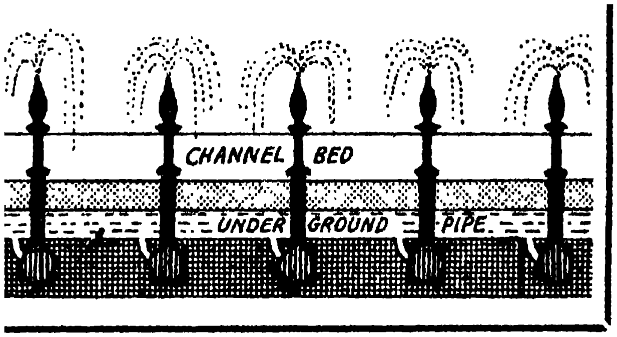


The Taj

detract the prominence of the Taj proper. Obviously, the builders could achieve everything that they aimed at.

How was the foundation laid? This is recorded in the *Badshahnama*, a contemporary text. According to it, the foundation was laid in the sub-soil water level, with stone-in-lime masonry below the ground and brick-in-lime above. Because of the proximity of the river and the slope of the bank, the entire foundation was made to stand on a compact bed of masonry. At the base are a series of deep

It is normally believed that to maintain uniformity of the pressure and proper distribution of water in the fountains at the Taj, pots or containers were fitted at the bottom of each of them (see fig below). Remains of earlier pipelines, unearthed recently, show this kind of arrangement which cannot be attributed to any one else but the architects of Shah Jahan. The recent theory that it belonged to the garden of Raja Jai Singh is not so convincing. The rise in the levels of garden beds was perhaps a result of the process of accumulation of earth during the later Mughal period when perhaps nothing was being done to maintain the garden in proper form.



On page 5, the picture on the right shows Taj minarets. The minarets on the left stand on the gate of Akbar's tomb at Sikandara in Agra

Sabz-Burj (left), an early Mughal tomb of an unknown person. This seems to be the origin of the design of the Taj proper. Below is the tomb of Sikandar Lodi. Compare this with the Octagonal tomb of the Taj at left (facing page)

Is the Taj sinking?

IS the Taj in danger? In his book *The Immortal Taj*, R. Nath, professor of history at the Agra College, warns that the Taj is in danger, as revealed by " the inclination of the marble plinth towards the riverside by more than an inch and the inclination of the minarets, one of which has gone as much as 8·6 inches (21·05 cms) out of plumb ". This " inclination on the horizontal axis of the plinth is sufficient proof that it is inclining towards the river as a whole ".

Cracks had developed in the Taj just four years after its completion. These were repaired as mentioned in the main article. Though repairs were done again between AD 1810 and 1814, the cracks later developed to dangerous proportions, and an Advisory Committee was set up in AD 1874 on the restoration and conservation of the Taj.

A survey by the Committee revealed that the plinth on the northern or the riverside is lower than on the south by 1-11/25″ (about 3·5 cms) and that the minarets were out of plumb. Recent studies have shown that all the four minarets have been inclining, the south-western at the rate of 0·5 inch (1·25 cm) and the other three 0·1 inch (0·25 cm) per 25 years. "The south-west minaret is in the most dangerous condition."

The " cracks too have developed dangerously in the second storey, mainly on the apex of the vaults and ceilings, and on a much larger scale in the underground vaults and also in and around the base of the massive piers near the marble plinth in the main tomb. Here the huge marble slabs have sometimes been crushed to pieces ".

Since there were no cracks on the exterior wall then, the experts on the Committee had ruled out any subsidence. The difference in plinth level, according to them, was either intentional or a constructional inaccuracy. Nath, however, argues that inaccuracy is inconceivable, since the masons had used " well-tried and perfectly evolved ancient Indian architectural canons " and tools like *sutrastakam* which ensured precision. Besides, there was no inaccuracy anywhere else. Similarly, though some archaeologists maintain that the cracks on the roof of the underground chambers were left intentionally by the builders to provide for horizontal expansion and contraction, others today discount this theory.

"All this proves that something has gone seriously wrong with the foundation," concludes Nath. The cracks, he argues, are not due to some leakage of water into the foundations, nor due to any underground shock movement. In both these cases, the cracks would have been continuous from one storey to another, and the minarets would not have inclined. The whole massive edifice appears to be sinking towards the riverside. "A structure which stands at the end of a stylobate just on the edge of water has a natural tendency to move towards the more open side, the higher edge always acting as a strong buttress, thrusting it on the opposite direction".

" There is no doubt that the builders of the Taj were conscious of this danger. That is why they bonded the whole mass together, with the very best materials, into a compact body. It, however, began with the displacement of soil beneath the foundation on the riverside. It is the whole mass, and not a part of it, that is very gradually sinking. This is what can justifiably be concluded from the available data.... Such sinking would also shift the load out of balance slowly and gradually and the unequal settlement would crack the weak points, particularly the soffits of the vaults and arches, which is actually happening in the underground chambers."

The Department of Archaeology, which looks after the preservation of monuments, says " there is no reason for any alarm ". But Nath is doubtful. " Will this grand majestic memorial be left to its fate to crumble down and vanish into the cruel waters of the Jamuna? Will the architect of the Taj Mahal have to pay such a high price for selecting the site so near the river? " he asks.

The Taj for sale . . .

Early in the 19th century, the British viceroys in India, Warren Hastings and William Bentinck, planned to demolish the marble structures in Agra. The intention was to send the marble to England, or to raise money by selling the marble. A hammam (bathing complex) in the Agra Fort was, in fact, dismantled and sold, and even an advertisement was placed putting the Taj up for auction. But the hammam did not fetch the price expected and this discouraged the viceroys from selling the Taj. Meanwhile, the British Government in England also stopped them from going ahead, on report of the intended sale by an English military officer.

" The Taj itself would have been pulled down and sold in the same manner ", writes W. H. Sleeman in his *Rambles and Recollections of an Indian Official*, if part of the material of the hammam auctioned had " fetched the price expected ". Or, as is said, an English military officer had not privately reported the proposed sale to the British Government in England. This prompted the British Government to issue an order prohibiting the sale. The Taj was saved.

R.C.S.

endowment of about 30 villages yielding an annual revenue of a lakh of rupees supplemented by the rent of the shops and inns within the complex.

He was justified too. Repairs had to be carried out even within a few years after construction. The earliest reference to the repairs to the Taj is found in a letter Aurangzeb wrote to Shah Jahan in 1652. He wrote: " The dome of the holy tomb leaked in two places towards the north during the rainy season and so also the four semi-domed arches, many of the galleries on the second storey, the four smaller domes, the four northern compartments and seven arched underground chambers which have developed cracks. During the rains last year the terrace over the main dome also leaked in two or three places. It has been repaired, but it remains to be seen during the ensuing rainy season how far the operations have proved successful. The domes of the mosque and the Jammat-Khana leaked during the rains and were made water-tight. The master builders are of the opinion that if the roof of the second storey is reopened and dismantled and treated afresh with concrete over which half a yard of mortar grout is laid, the semi-domed arches, the galleries and the smaller domes will probably become watertight, but they are unable to suggest any measures of repairs to the main dome . . . . "

The modern threats are from floods, soil-erosion, silting and other natural agencies. The Archaeological Survey of India is taking adequate measures to protect and preserve the monument without, of course, disturbing the originality of the structure, for the basic principle of archaeological conservation is to retain the ancient character of a monument at all costs. These methods of conservation depend on the type of monument, the nature of repairs and the climatic conditions of the region. Some of the important conservation devices are given in the box on the right.

These measures include: removing vegetation from over the surface of the monument, consolidating the masonry, strengthening the damaged and weak points, watertightening exposed surfaces, filling up cracks, replacing decayed plaster and veneer ornamental stones with absolutely similar material. Recently, two oblong spurs, projecting from the right bank of the Yamuna into the riverbed, have been constructed to the west of the Taj near the Khan-i-'Alam garden to divert flood waters and check soil erosion. Yet, with a long-range view, it is necessary to see that the Taj surroundings remain undisturbed. It should be free from modern industrial establishments, railway-lines or other such factors to protect the Taj from the adverse effects of smoke and strong sound vibrations.

How to protect monuments

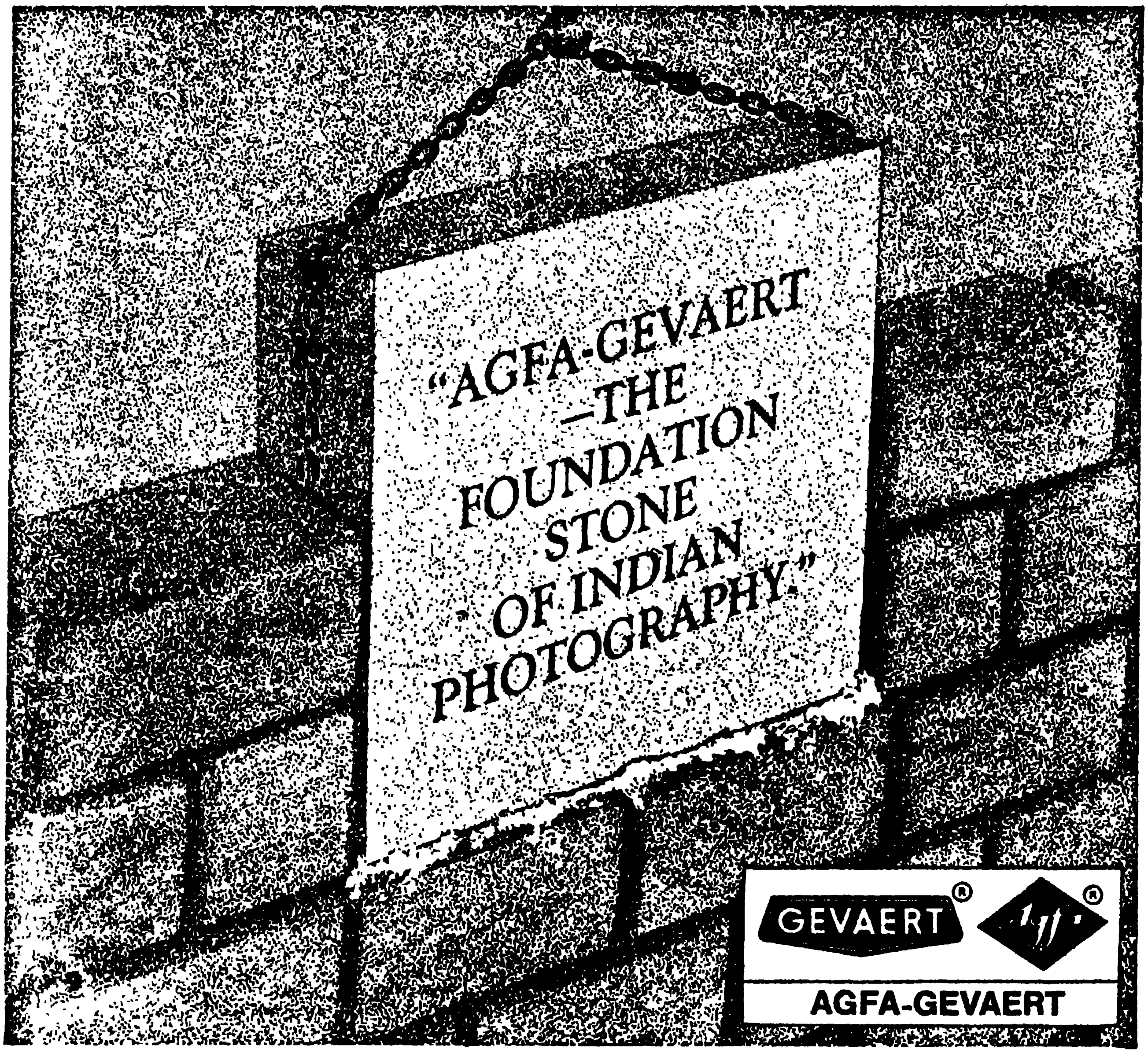
If the masonry is displaced, the bulged out portion of the superstructure is taken out and stones and bricks are rebedded in their original position. For easy identification, the stones are numbered while removing them. Dislocated or tilted domes or arches are also repaired in the same way after providing support or centring. Here non-corrosive metal clamps should be used; in no case should iron be used, except in reinforced concrete.

Internal (concealed) insertion of reinforced concrete beams is highly effective in strengthening walls with a pronounced "bow". Where high walls are to be repaired, additional beams should be inserted at a lower level by withdrawing the facing material and creating recesses for beams, and replacing the face work when the concrete is set. In the case of lateral support for a leaning wall, vertical reinforcement is preferred to external buttressing. This, however, should be done along with underpinning.

Defects in joints are rectified by removing dirt and loose mortar from within. The joints are washed with clean water using a hose or garden-syringe. Then the joints are filled with mortar and consolidated by pressing in with appropriate tools. A paint to match with the original colour and texture is then used. For water-proofing, the tops of structures, the upper courses of stone/brick, are lifted, cleaned and rebedded. Manual or machine grouting with liquid mortar, usually cement, is generally done to avoid the dismantling and rebuilding of defective masonry. In the case of minor fractures and voids, hand-grouting is preferred. For large voids or fractures, however, gravity grouting or grouting under pressure by machine is essential.

Chemical treatment of the exposed surfaces with proper preservatives is part of archaeological conservation. Erosion is checked by constructing spurs or walls with appropriate material or by using artificial concrete rocks. This, however, depends on the location.

M. C. Joshi is an archaeologist with the Archaeological Survey of India, New Delhi. He has specialised in Indian art and architecture.



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Among the mute witnesses at the scene of a violent crime—murder, rape, assault—are drops of blood. Over 90 types of human blood are now known, and by ultra-sensitive tests the forensic biologist is generally able to tell to which type a bloodstain (be it as small as a pin-drop) belongs—thus tightening the noose round the suspect's neck —or letting him out

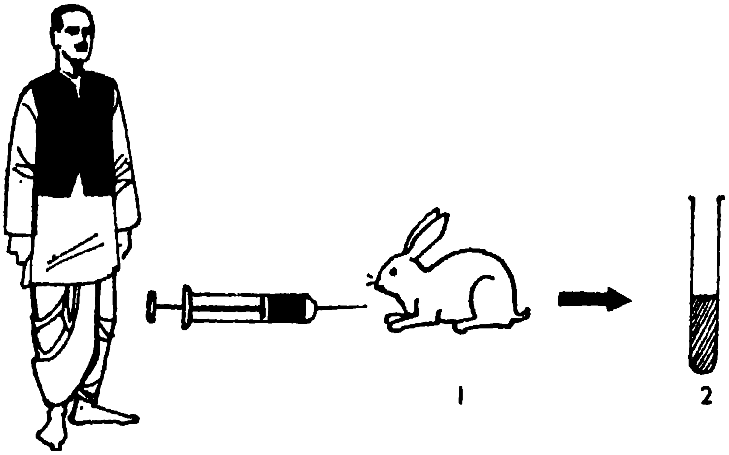
SCIENCE AGAINST CRIME—X

BLOOD WILL TELL

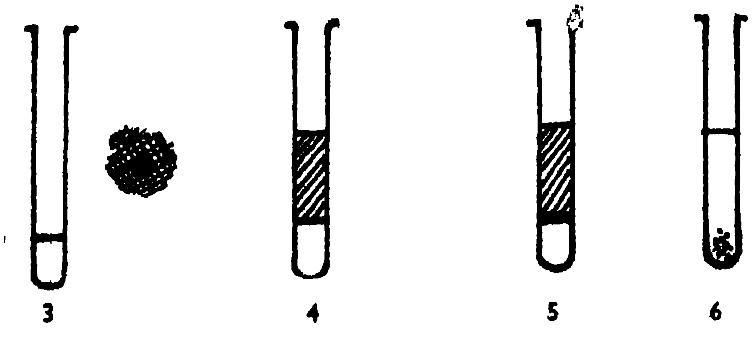
S. SIVARAM

VARIOUS materials like seeds, microscopic plants, hairs and fibres are found at the scene of a violent crime as trace evidence, but most often the question asked by the police is: " Does the blood on the accused's clothes or weapon match the blood of the victim? "

In October 1947, a lady was thrown out from a first class compartment of the Calcutta-Bombay mail train. She escaped death by landing on the sandy bed of a *nulla*. She lodged a complaint of assault and robbery with the nearest police station. The train was detained at Harda while police officials came up by a following train. The Dy. SP noticed a few bloodstains in the I class compartment and a purse containing currency notes in the toilet. Just next to the compartment was the dining car. A bearer of the dining car was found to have a cut on his right thumb, which he said he had received while cutting onions. Further investigation revealed a bloodstained shirt in his possession. On being confronted with this, he confessed that he had attacked the lady with a knife after finding her travelling alone.



In the precipitin test for bloodstains, human blood is first injected into a rabbit (1) to produce " anti-human serum " (2). An extract of the suspect bloodstain (3) is then tested against the anti-human serum in a test-tube (4). Only if the bloodstain is human will the ring (5) or " precipitate " (6) be produced



Later, the bloodstains on the lady's blouse and on the bearer's clothes, as well as the knife, were examined by the Chemical Analyser. They matched with the blood of the lady passenger but not with that of the bearer. Medical opinion was that the cut on the bearer's hand had been received within less than 24 hours. The bearer was convicted and sentenced to seven years' RI.

A discerning investigator can learn a lot by studying the size and shape of blood spots at a crime scene. He can deduce their point of origin, the distance of fall and velocity of fall. In one case a lady was stabbed through the heart while in a car. A large quantity of blood had flowed on to the right side of the chest; a larger quantity of serum (the liquid portion of blood after clotting) had flowed round the left side after clotting and to the back of her clothes. From these facts it could be deduced that she was sitting or reclining partly to the right when the weapon was withdrawn. From the extensive clotting of the blood shed internally, from which the serum had later escaped, it was clear that the body had not been moved for some time. It had been moved to a reclining position, tilted somewhat to the left, and during carriage the head was low, allowing the serum to flow over the left shoulder and down around the left side of the neck. The sequence of events was important in reconstructing the actions of the murderer.

In a crime of violence such as murder, the victim's blood often stains the miscreant's body and clothing. Its presence alone is evidence of guilt, but its distribution helps in reconstructing the events in the crime. The victim's blood on a weapon helps confirm that the weapon was used in the crime.

The criminal may sometimes leave traces of his own blood at a crime scene. During the struggle he may be wounded, thus depositing his own blood on the victim or the weapon. The victim may scratch him, and thus get traces of the assailant's blood on his finger nails. A burglar while forcing a window may get cut by a broken glass pane or protruding nail, and thus leave a valuable clue in the form of his own blood.

When an article believed to bear a blood stain, found at a crime scene, is sent to a forensic science laboratory for examination, the forensic biologist has first of all to determine whether any blood-stains are present. The criminal may have washed the garment to remove traces of blood. The stains may be contaminated or obscured by other material. Blood stains may not be quite visible on dark fabrics, but on examination under ultra-violet light, they will appear as dark patches.

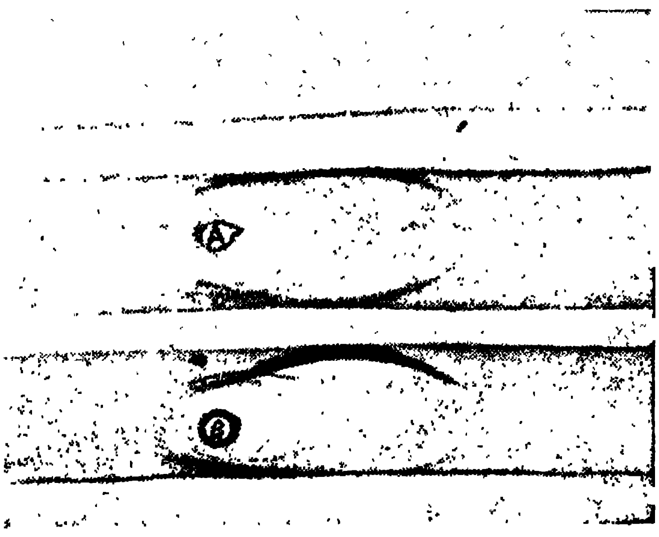
As blood stains get older, they become darker, but this is not a safe index of their age. Heat, sunlight, washing and putrefaction influence the aging of blood stains and the speed at which these changes take place. It is rarely that fresh blood specimens are received by a forensic laboratory for examination. The only samples of liquid blood received are those taken from victims of crime when it became important to know their blood groups and match with stains on a weapon, the suspect's clothing, or a sample from the suspect himself for purposes of elimination. Most of the specimens received are dried blood stains. Drying damages the envelopes of the blood corpuscles that carry the blood group " receptors " and hence it is not easy to obtain a cell suspension that can be grouped by the ordinary " agglutination " methods applicable to liquid blood.

Is it blood?

THE FIRST QUESTION the forensic biologist has to answer is " Is it blood at all? " Blood of a vertebrate contains red blood cells and white blood cells; the former contain the red protein haemoglobin. Liquid or moist blood can easily be identified under the microscope by the presence of these cells. It is a little more difficult to identify dried blood. For this purpose, the benzidine or phenolphthalein tests are used; the haemoglobin of blood, in the presence of hydrogen peroxide, induces chemical reactions in benzidine or phenolphthalein (which are colourless) to form blue or pink coloured compounds. But these colours which indicate a positive reaction are also produced by fresh fruits and vegetables. The method of choice, however, is absorption spectroscopy. This is based on the property of haemoglobin, and its derivatives, of absorbing light of certain wavelengths; when a blood-stain is examined in a spectroscope, the spectrogram reveals the bands that are characteristic of the wavelengths absorbed by haemoglobin derivatives.

The next question that must be answered during the examination is whether the blood is from a human or other animal or even a bird or fish. What distinguishes mammalian fresh blood is the absence of nuclei in the red cells. On blood stains, the serological " precipitin test " is employed. The question of non-human animal origin comes up in cases of butchering of stolen cattle, game law violations, and

Monkey serum (A) can be distinguished from human serum (B) by testing it with anti-human globulin serum prepared from rabbit, using electrophoresis (see p. 52)



Blood grouping test in progress (see page 52)

adulteration of meat. The test used is based on the fact that an animal normally contains and can tolerate only its own types of proteins. If protein from another species (antigen) is injected into it, a protective or " immunising " reaction takes place; the animal generates an antiprotein (antibody) which will precipitate the foreign protein, or make it insoluble, thereby making it non-toxic to the animal.

This principle is employed in the " precipitin test." A rabbit is injected with the globulin portion of human (or other species) blood; the rabbit produces antibodies against the injected globulin. Blood serum from the immunised rabbit, commonly referred to as anti-serum or anti-globulin serum, when mixed with even very dilute extract of the specific blood stain will produce precipitation of the protein of the blood. For example, when the anti-serum is mixed with blood from a different species, no such precipitation will occur, unless that species happens to be closely related to man, eg, ape or monkey.

The test is carried out in tubes (ring test) or in gel plates (gel diffusion test). A positive reaction is indicated by a ring of white precipitate forming about the junction of the two fluids in the former and a white line in the latter.

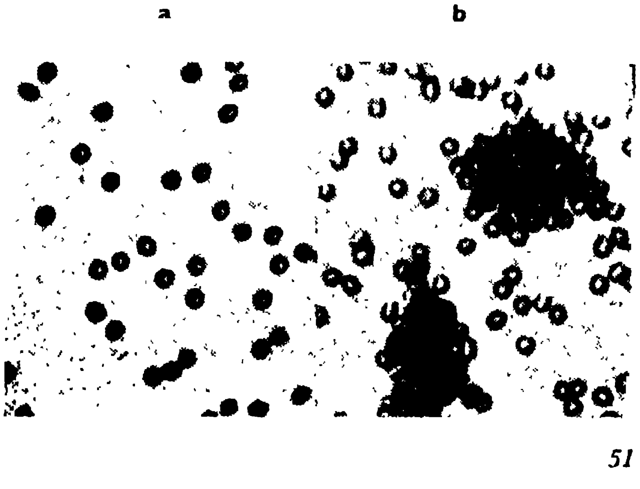
In many cases, all that is necessary is to establish that the blood is human. (For instance, in a murder case a taxi-driver killed a woman passenger near Delhi's Palam airport, carried the dead body in the boot of the taxi and later burned the body. When the taxi was recovered after some months, it had been washed clean of all stains. However, the small quantity of dust collected with a brush from the boot revealed under the microscope several wool fibres identical with those from the partly burnt coat of the victim, and the dust also gave positive test for human blood.) The blood stain from a weapon is transferred to a moist cotton thread for examination along with " control " threads. An anti-human globulin serum is used first and if the test is " positive," the specimen is human blood. If the test is negative, it means that the blood is either non-human blood or that the proteins in it have broken down to the extent of being inactive; it then becomes necessary to test for the presence of proteins belonging to other species.

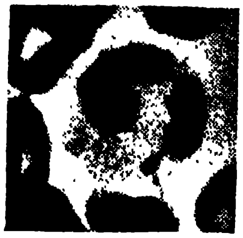
Blood grouping

HAVING ESTABLISHED that the specimen of blood or blood stain is human, the forensic biologist is faced with the task of grouping it. Blood too has its individuality, and now over 90 types of human blood under more than 14 independent systems are recognised; as the types are genetically determined, are independent and do not change in a person's lifetime they are useful in identification and/or elimination.

There are three principal ways in which human blood can differ. The first is with respect to the cell walls of the red blood cells, as is illustrated by the ABO system, the first to be discovered. The ABO system consists of four main types designated as A, B, AB and O. Serum of A group blood when added to B group blood will cause the corpuscles of the latter to clump together or agglutinate. Serum of B group will clump the cells of A group blood.

a. Normal red blood cells look like this under the microscope. b. What is seen when they agglutinate or clump





B

Occasionally it becomes necessary to determine whether a specimen of blood is from a man or woman. This is possible in liquid blood because some of the white blood cells of the female contain " drumsticks " (shown by arrow in B) peculiar appendages of the nucleus. A: similar cell from a human male

Blood contains an antigen (agglutinogen) in the cell and an antibody (agglutinin) in the serum. When B blood serum is added to A blood, the " anti-B " agglutinin in the former reacts with the A agglutinogen, of the A cells, causing the clumping of the blood cells. There is also the O type which is not agglutinated by serum of the other three types, and the AB type which is agglutinated by O, A and B, but not by AB serum.

An unknown sample of blood can be grouped by noting which known sera agglutinate its corpuscles and/or which known corpuscles are agglutinated by its sera. There are now known to be several subgroups of A, of which A_1 and A_2 are common enough, giving six groups under the ABO system. In the Union Territory of Delhi, B group is the most common, occurring in about 40 per cent of the population, followed by O group (32 per cent), A group (20 per cent) and AB (8 per cent).

There are a large number of other group systems, eg, MNS system (the M antigens of which are detectable in stains aged up to nine months), the Rhesus system (which includes the antigens C, C^w, c, D, E and e), and numerous less known systems such as Lewis, Lutheran, Kell, Duffy, Kidd, Diego and Wright. The Kell antigen was successfully determined in an actual case of homicide in England in 1955.

It is not possible to use direct agglutination tests for blood stains, because the red cells will have been dried up. Also, the amount of material may be limited to a few spots, often washed; or the stains may be contaminated with bacteria or dirt; or the antigens may not be active enough. Tests used for detecting antigens in stains may be: 1) Indirect inhibition, 2) Absorption-Elution, or 3) Mixed cell agglutination tests. These methods are reliable for the ABO groups, but not reliable for MNS and Rh systems under Indian conditions.

In the indirect inhibition test, known sera were added to the dried stains or its extracts, and after a period of absorption, the residual sera were tested with known red cells. A substantial reduction in the strength of the absorbed serum was evidence of the presence of the corresponding agglutinogen. This method has drawbacks like low sensitivity.

With the modern micro-methods of absorption-elution or mixed cell agglutination, instead of testing the residual serum, reactions are obtained directly from the absorbed antibody. Minute pieces (3 mm) of stained threads are tested for the dried red cell debris attached to them. It is necessary only for a small portion of the antibody content of the added serum to be absorbed to obtain a positive reaction. For large-scale application and ease in handling, minute 3 mm long threads from each stained and control cutting are attached at one end in horizontal rows (one thread for each for A, B and O group tests) to a sheet of cellulose acetate and tests are carried out on the teased free ends of the threads by adding drops of anti-A, anti-B and anti-H followed by washing and addition of known A, B and O group red cells. Plastic boxes are used for providing humid chambers for the sheets during the tests.

Protein composition

THE SECOND TYPE of difference in the blood of human beings is the protein composition of the blood serum and of red blood cell contents. There are antigenic differences inherent in the proteins, which have been used in evidence in criminal cases in England. The haptoglobins of serum as well as the haemoglobin or oxygen-carrying pigment of the red blood cells exists in more than one form, which can be identified by electrophoresis (a method which makes use of the differential mobility of molecules in an electrical field).

A large number of enzymes, eg, cholinesterase, which take part in metabolic reactions are present in blood. Each of these enzymes occurs

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NEXT MONTH:

CRIMINAL ABORTION

in several different forms, any one of which may be present in a person. Very reliable methods have recently been developed for their separation by electrophoresis in starch gel or agar gel, followed by identification by colour or precipitin reactions (immuno-electrophoresis) for forensic purposes.

Secretors and non-secretors

THE THIRD POINT of difference among human beings is whether they secrete the blood cell group antigens in other body-fluids such as sweat, saliva, and semen, or not. People can thus be divided sharply into " secretors " and " non-secretors ". The former, but not the latter, secrete the ABO and Lewis antigens and another mysterious entity, the " H-substance " in a high concentration in their sweat, saliva and semen. Whether it is a semen stain on the clothing of a victim of sexual assault, or saliva on a *beedi* or cigarette stub, stamp gum or envelope flap, or sweat on clothes or a hat left behind at a crime scene — these can all be referred to their groups in the case of secretors.

What is important is that all the blood group systems are inherited independently of one another, the genes responsible for the antigens being distinct entities, and hence the number of permutations in which they occur is very large. The greater the number of systems under which a blood stain can be grouped, the more definite is its identity, and the smaller the number of persons from whom it can have come. Thus, it is possible that the time will come when it will be possible to individualise blood to the point where it is possible to tell from which particular individual a blood stain came from.

Disputed paternity

BLOOD GROUPS ARE also used in establishing the parentage of a child in cases of disputed paternity. All known blood groups are inherited on similar lines, according to the well-known Mendelian laws : 1) A blood group gene cannot appear in a child unless present in one or other or both parents, 2) If one or other parent is homozygous (having two similar genes for a particular character) for a particular blood group gene, it must appear in the blood of the child.

Dr. S. Sivaram is Assistant Director (Biology), Central Forensic Science Laboratory, New Delhi.

HOW NOT TO CALL A SPADE A SPADE

ERE are some clichés used by scientists, which don't quite convey the facts, or convey the opposite:

It has long been known — I haven't bothered to look up the original reference.

Of great theoretical and practical importance — Interesting to me.

While it has not been possible to provide definite answers to these questions — The experiment didn't work out, but I figured I could get publicity out of it.

Extremely high purity — Composition unknown except for the exaggerated claims of the supplier.

Three of the samples were chosen for detailed study — The results on the others didn't make sense and hence were ignored.

Accidentally stained during mounting —Accidentally dropped on the floor or otherwise contaminated.

These results will be reported at a later date — I might get around to this some day if the new grant comes through.

The most reliable values are those of Agarwal — He was a student of mine.

It is generally believed that — A couple of other guys agreed with me over coffee the other day.

It might be argued that — I have such a good answer for this objection that I shall raise it now.

It is clear that much additional work will be required before a complete understanding — I don't understand it either.

It is to be hoped that this work will stimulate further work in the field — This paper is not very good, and does not arrive at any definite conclusions.

Thanks are due to Mr. X for the assistance with the experiment and to Mr. Y for valuable discussions — Mr. X did the work and Mr. Y explained what it meant to me.

D. C. Uprety

Dr. Uprety is with the Cummings Laboratory, Indian Agricultural Research Institute, New Delhi.]

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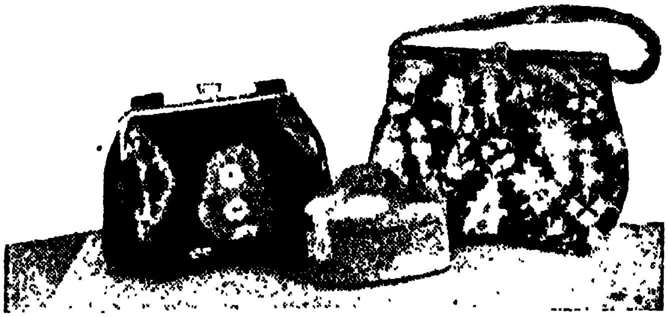
Fancy Leathers from Rejected Skins

THE ancient art of tie-and-dye printing on textile fabrics is now being used to turn out fancy leathers from low-grade sheep- and goat skins, which were usually rejected. The *Bandhani* technique, as the process developed at the Central Leather Research Institute, Madras is called, masks all the defects of these skins by producing brilliant, multi-coloured floral effects, upgrading their value by as much as 200 to 300 per cent.

The problem of profitable disposal of rejected skins has been a big economic issue with the Indian leather industry. It is said that selection of good skin is limited to only 15 to 20 per cent in respect of goat skin, maybe slightly better in respect of sheep skin. This huge waste is attributed to factors like pre- and post-mortem caring and curing of the skins. The *Bandhani* technique promises to make good the butcher's lack of expertise.

The new technique is the invention of Mr. P. S. Venkatachalam, Mr. J. K. Khanna, Mr. K. B. Gupta, Mrs. R. Khanna, and Dr. Y. Nayudamma. It is a combination of the tie-and-dye method of textile printing and the traditional method of manufacture of suede leather by full chrome process. The skin is first soaked overnight in water containing a suitable wetting agent and 1 per cent ammonia. It is then squeezed to remove excess water, laid on a table and the desired design pattern marked on its grained side, using a template. It is now tied with twine at particular spots (according to the design pattern), using slender sticks to support the knots, and dyed to a pastel shade in a tub. After the dye is fixed with formic acid and the skin rinsed in water, the knots are untied and then retied at about the same places but with slightly extended areas for tie-dying. This time the skin is dyed to a slightly darker shade using a contrast colour. The process may be repeated a third time using a still darker shade. The dyed skin is finally rinsed in water, squeezed, untied, dried on toggle frames, and given a fixing treatment followed by shower-proofing. Subsequent treatments are the same as required for producing normal suede leather.



These attractive items — a garment, ladies' handbag and jewel case — have been made from low-grade skins improved with the *Bandhani* technique

Bandhani leather can be used for making a variety of sophisticated fashion goods like garments, gloves, wallets, bags, pouches, slippers and children's footwear, besides many types of novelties. The leather is being produced by a number of tanneries in the country, both for export and indigenous consumption. Because of its psychedelic look, *Bandhani* could be a craze with the new generation of Americans and Europeans. ● ●

Device that Feeds Balls to Furnace Automatically

AN automatic device developed to feed steel balls into shaker hearth furnace for heat treatment does the job much more efficiently than the human operator it has replaced. Thanks to it, the engineering firm, where its inventor Mr. M. L. Verma works as

(*Continued on page 57*)

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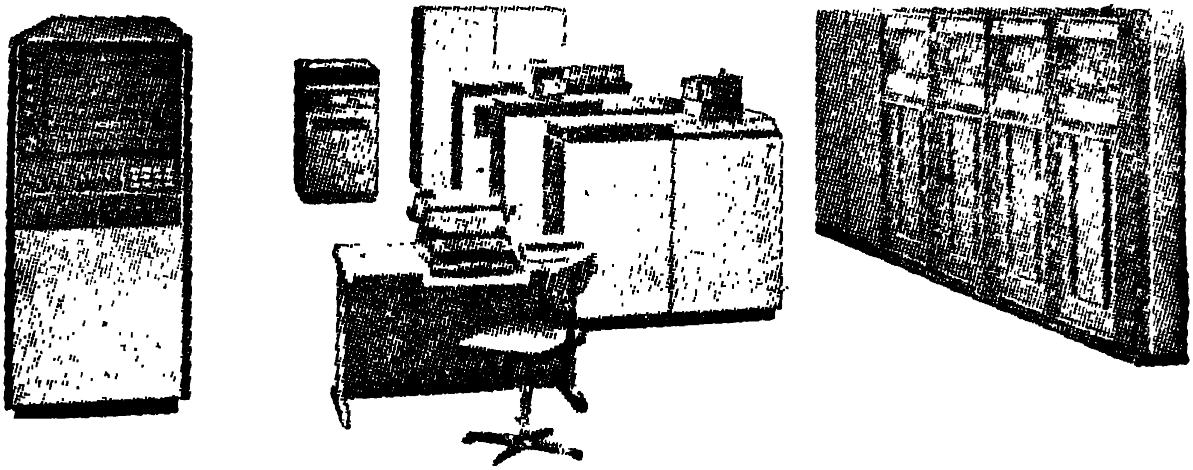

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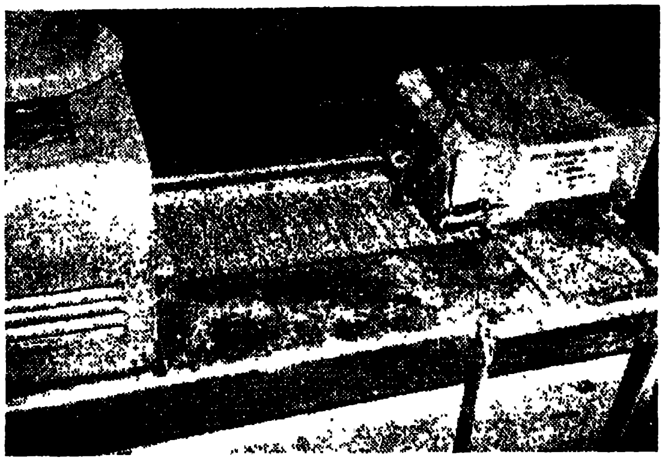
(Continued from page 55)

production supervisor, has no longer to lose production on account of the operator's absenteeism or negligence in feeding the balls with regulated constancy. In fact, their production has picked up by about 20 per cent and the quality of the treated balls as also improved considerably due to uninterrupted and regulated feeding.

Steel balls are extensively used in such engineering products as ball bearings. To make them hard and durable, the balls are heat-treated in a shaker hearth furnace at 850°C and then quenched in oil. In the conventional practice the balls are fed to the furnace by placing them manually on a hearth plate, which due to the periodic jerks that it receives keeps the balls rolling on through the furnace in a controlled manner. Manual feeding being a monotonous job, the operator is apt to feed a smaller number of balls than the furnace is capable of treating, causing loss in production.



. . . improves production by 20 per cent

Mr. Verma's automatic ball feeding device does not need any external source of power to operate. It is simply a container of steel balls with a trap door that opens at every periodic jerk of the hearth plate. The door opening can be adjusted to allow only a pre-determined quantity of balls to be released on the hearth plate. One can thus get the best output from the furnace by suitably adjusting the feed rate.

The device can be designed to suit automatic feeding of any small symmetrical components, like balls, pins, rollers and bushes, says Mr. Verma. It is particularly adaptable to furnaces or machines that have periodic strokes, which provide the necessary jerk for gate opening.

Badiuddin Khan

in lighter moments . . .

WILLIAM Herschel was once in the Hanoverian army. He deserted, decamped to England, and became an astronomer. His discovery of the Uranus shot him to fame; he was appointed Astromer Royal by King George III.

To wend his way through the heavens, Herschel made several telescopes. These became the 'in' things of the day, and everyone wanted to have one. It mattered little whether the owner knew how it worked. One among such proud possessors was William Pitt, the renowned statesman.

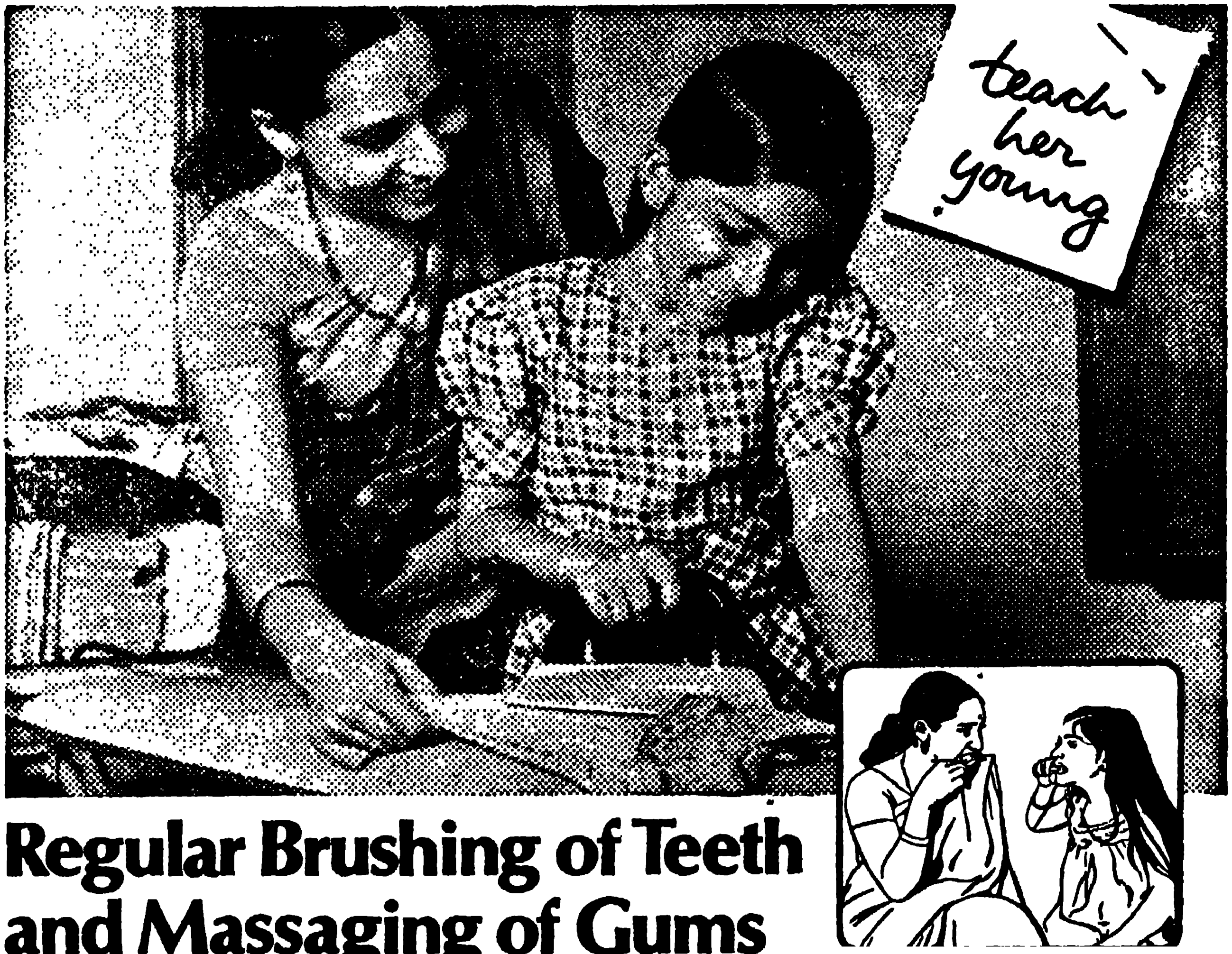
Once the King, accompanied by the Archbishop of Canterbury, paid a visit to the stargazer's workshop. A huge 12-metre (40-feet) metal tube lay on the floor. What was it like inside? Herschel offered to show them. In they went, the three of them, but the church minister found he couldn't walk with ease. The gallant' astronomer just behind him offered his hand and said, " Come, my Lord Bishop, take my hand, I will show you the way to heaven! "

● ● ●

ALFRED Nobel had blasted his way to riches and was living happily at the age of 53, when his brother Ludwig passed away. A Nobel had died. By mistake, a provincial newspaper reported that Alfred, the discoverer of dynamite, was no more. In the obituary, he was called " merchant of death " because of his scientific and industrial achievements in the field of explosives. Alfred was terrified. If this was the title posterity had reserved for him, he had better do something about it. His mother's death deepened his obsession. He decided to make amends — and the Nobel Prize was born.

MONK Mendel might have agreed that marriages were made in heaven, but for humans alone, not for bees. He attached the hive to a wire cage and let the queen in with a number of suitors. A visitor noticed the segregated insects and asked why these were separated from the rest. Mendel replied: " I have put a queen together with a number of drones. The queen is choosing a proper husband, for it is just as important among bees, as it is among human beings, when a good woman is mated to a bad man ! "

S. N. Munshi



Regular Brushing of Teeth and Massaging of Gums Check Gum Troubles and Tooth Decay.

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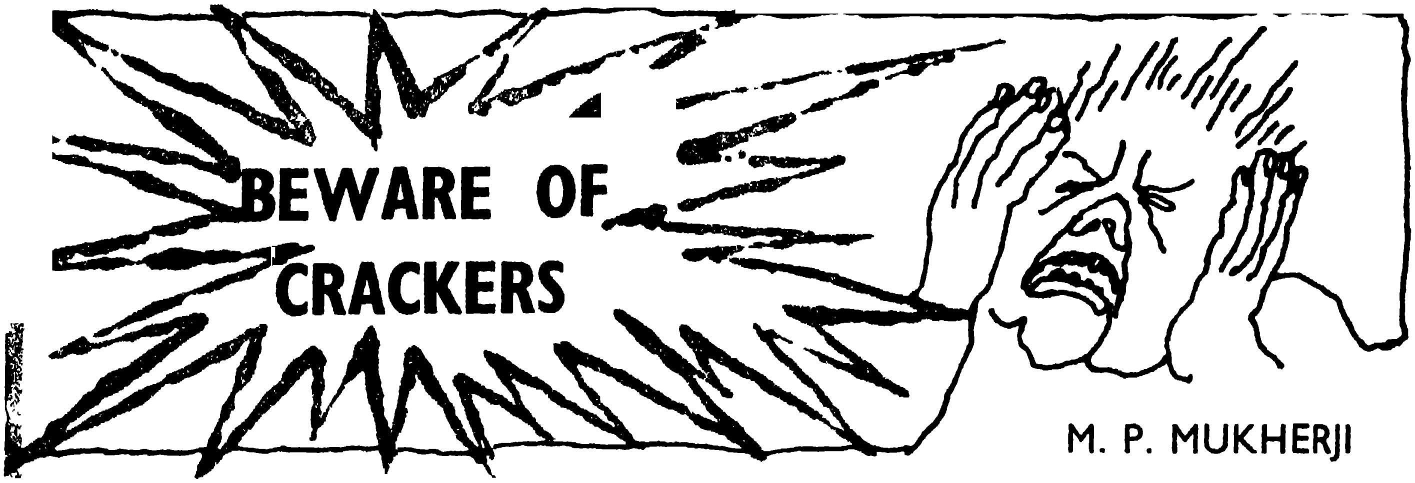


BEWARE OF CRACKERS

M. P. MUKHERJI

DIWALI is the greatest festival of the year for children. Crackers welcome the dawn; and bangers (bombs), spinwheels (*jamin* and *hath chakra*), fiery fountains (*anar*), sparklers (*phuljhari*), rockets, etc herald a week which is the noisiest and brightest of the year.

Both young and old join the fun. And hardly anyone seems to remember that their fun can become the cause of a dangerous fire. A smart fellow starts demonstrating a novel way to play football by kicking a lighted *jamin chakra*. Or, somebody decides to be Werner von Braun for a night and starts playing with rockets. Not infrequently, carelessness leads to tragedy.

Have you met the fellow who makes crackers sound louder by bursting them inside a tin can? That is how he converts a safe cracker into something very close to a live bomb which could injure, even kill, persons nearby. Often children light more than one cracker simultaneously to get a loud noise. If one cracker bursts before the others, the explosion can throw the other lighted crackers on nearby persons. There are others who specialise in retrieving misfired crackers. Quite often a misfired cracker bursts unexpectedly just when someone tries to relight it. In the process, he could get a bloody nose or lose an eye. It is dangerous and not worthwhile to retrieve a misfired cracker.

Throwdown crackers do not have any fuse. They are exploded by impact on a hard surface. They contain one of the most sensitive and dangerous explosive compositions. A slight impact is enough to set them off. Throwdowns are capable of exploding even when handled carefully and gently. Over a thousand persons have been killed while making or handling throwdowns. There is no count of those who have been injured due to unexpected bursting of throwdowns.

Have you rubbed a *chatpati* — also called *tartari* or *putputia* — on the ground ? It looks like dots of chocolate pasted on a strip of paper. The dot when rubbed on a rough hard surface jumps from place to place giving out crackling noises. Many inquisitive children have died while trying to find out how it tastes. The dots contain a strong poison, white phosphorus. These are banned, but thanks to the unauthorised manufacturers, a few are still found in the market.

There is a cheap substitute for crackers. It is a powder, yellow or yellow-orange in colour. A small pinch of this powder when placed on a hard surface and hit with a hammer or stone explodes with a sound louder than ordinary crackers. The powder is extremely sensitive and dangerous. The same powder is used in the dangerous throwdowns we talked of earlier.

Ingenious persons have devised another dangerous apparatus for producing cracker-like noises by exploding a mixture of acetylene gas and air in a can. The gas mixture is generated by wetting a small lump of calcium carbide kept in the can and igniting with live fire. "Bursting cans" of this type could fly with force in any direction and seriously injure people.

How does noise affect you?

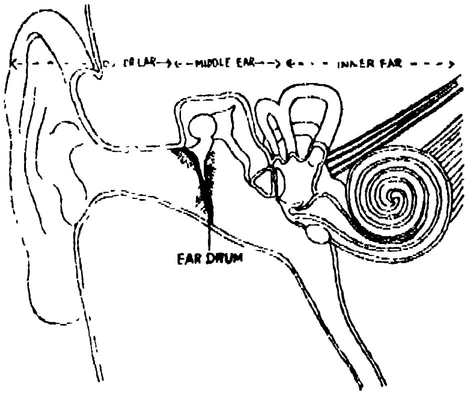
The loudness of sound is measured in decibels. During normal conversation, the sound level is 60 dBs; in a domestic quarrel it reaches 80 dBs. About 90 dBs is the limit which we can stand without any adverse effects. Above this level sound can be dangerous. Around 120 dBs is the pain-threshold, and 140 dBs is the limit of tolerance.

No study has been done so far on the noise nuisance of crackers, but it is generally agreed that sudden, startling, loud sounds like a gun-shot report, can affect man. But here, the noise is expected.

When we hear, the sound waves hit the ear drum. This vibrates. The vibrations are passed on to the fluid-filled inner ear through the air-filled middle ear by means of three small bones. The fluid in the inner ear stimulates thousands of tiny hair cells producing electrical signals that roughly correspond to the vibrations received by the outer ear. These are transmitted to the brain by the nerves.

The simultaneous explosions of several crackers could well produce noise levels detrimental to the ear. Violent explosions can tear the ear drum. This will lead to bleeding, infections and chronic ailments. Young children and old people are more susceptible than others. It could throw a person into shock — the person may feel giddy and vomit. Profuse perspiration, cold clammy hands, and palpitation could occur if the degree of shock is greater. Expectant mothers, particularly those in the last three months of pregnancy, should take care not to expose themselves to the sudden loud bangs — they could abort. Similarly, sick persons, particularly cardiac patients, should be screened from such noise.

Do not take little children near a bursting cracker They surely will not enjoy it. In fact, one occupational scientist suggests the use of cotton ear plugs to shield the ears; it is better if the cotton is dipped in oil. The effect of the sound is greater in a closed room because it cannot be dissipated. So fire crackers outdoors.



. . . and the gases?

You may have noticed the drastic fall in the mosquito population around Diwali. This could mean the gases are harmful. As long as you light all your fireworks in open spaces, there is no danger. But in confined places, the concentration of the gases can build up sufficiently to cause irritation of the eyes and the mucus membrane of the upper respiratory tract.

For example, a gas like carbon dioxide in concentrations of more than 8 to 15 per cent can cause dizziness and nausea. If prolonged, it can lead to unconsciousness, and death may follow. Carbon dioxide is given out by almost all burning organic matter. If sufficient oxygen is not present, carbon monoxide is formed. This is a toxic gas; it can kill by affecting the blood's oxygen-carrying capacity.

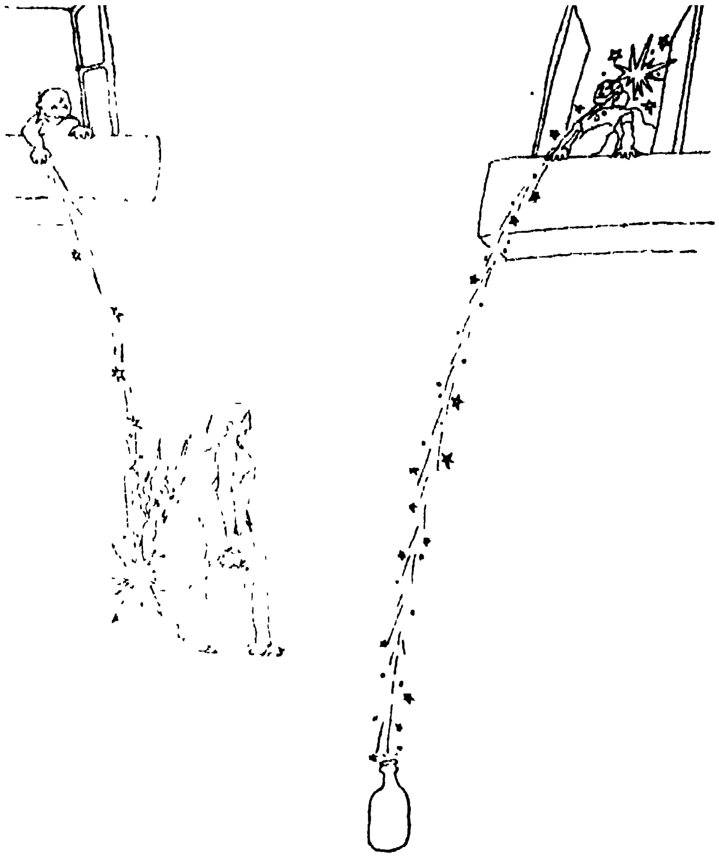
Barium salts are used to impart green colour to the flame The soluble barium salts are poisonous. If such a firework were to fall into the hands of a young child, it could be dangerous. They irritate the skin and the mucus membranes, and produce dermatitis. Inhaled fumes can cause bronchial irritation. Of the nitrogen oxides formed from the pottasium nitrate used in gun-powder, nitrogen dioxide is very irritating to the eyes and the mucus membranes of the respiratory tract.

Again, sulphur dioxide from the sulphur can affect the air tubes and the lungs and cause pulmonary oedema.

Remember : Manufacture, possession, sale and use of throwdowns, yellowish or yellow-orange powder and " corks " for toy revolvers and guns mentioned here are prohibited under the Indian Explosives Act. Rockets having metal cases and *putputlas* are unauthorised fireworks.

Firing of crackers inside a can constitutes rash and negligent act punishable under the Indian Penal Code. It is unlawful to display even authorised types of fireworks in a public place without a permit from the local authority.

Under the Explosives Rules, no one can manufacture fireworks for personal use or for sale unless he has a licence to do so.



Rockets shoot into the sky, but they do so only when fired with the nose pointing upwards. Do not be surprised if a carelessly fired rocket shoots out horizontally and hits the baby standing there or enters a room through the window and sets the house on fire. If the rocket has a metal case, it can cut deep into the body of a person standing on the path of its flight.

Then there are the " American-design " revolvers which look exactly like a real one and also double-barrel toy guns. These revolvers and guns fire special cartridges made of cork. When fired, the cork cartridges give a loud report accompanied by a flash. They contain the same prohibited and dangerously sensitive explosive composition which is used for making throwdowns. Particles of grit mixed with the composition are thrown towards the person who fires the " weapon ". If the weapon is held at eye level, as is usually done for firing, the eyes of the *shikari* will receive the shooting particles of grit. With what results, you can well imagine.

Many safe fireworks are available in the market but even the safest type could be dangerous if not fired properly and carefully. A lighted ground chakra when kicked about could lodge itself between the folds of your dress and cause serious burns. Remember! Fire does not forgive even an innocent person.

Play with fire the safe way

Does the little one want a sparkler ? Why not improvise a long wooden handle instead of putting one directly into his hand. Just around the time of Diwali, there is a marked increase in the number of fire accidents. According to statistics obtained from the Bombay Fire Brigade, on an average there have been about 45 fires annually due to fireworks in the past five years. The losses run into lakhs of rupees each year. Also, serious burn injuries can permanently disable a person both physically and mentally.

Have you bought your fireworks from reputed manufacturers ? You are asking for trouble if you haven't. Fireworks manufacture is a cottage industry, and several unemployed people try to make them at home. Ignoring rules and regulations, they use prohibited chemicals. These may be dangerous or toxic. The throwdowns and Bengal matches are easily ignitable and even dropping them amidst a bundle of crackers could create havoc.

To be on the safe side, don't let children be by themselves when lighting fireworks. Avoid wearing clothes that catch fire easily. Even a tiny spark could be fatal. Keep the firework stock locked up, give them only a few at a time. Don't let them keep fireworks in the pockets or in their hand while they are lighting something.

When lighting a new type of cracker, make sure how it works and don't hold it in your hand unless the instruction says so. Remember, a cracker can behave unpredictably. As a rule, it is safer to light crackers in the open. Throwing lighted crackers from balconies has caused several accidents even fatal ones. Discard the remnants of burnt crackers into an earthen or metal container.

If a firework fizzles out, don't go near it immediately. Wait for at least 15 minutes before retrieving it. (It is better to douse it with water from afar and discard it.) If the fuse has been cut short while handling, remember you have less time to run to safety.

Finally, keep a bucket of water handy, should an accident occur. (See *Science Today*, p. 58, May 1973.)

Mr. M. P. Mukherji is Chief Controller of Explosives of the Government of India.

NEXT MONTH:

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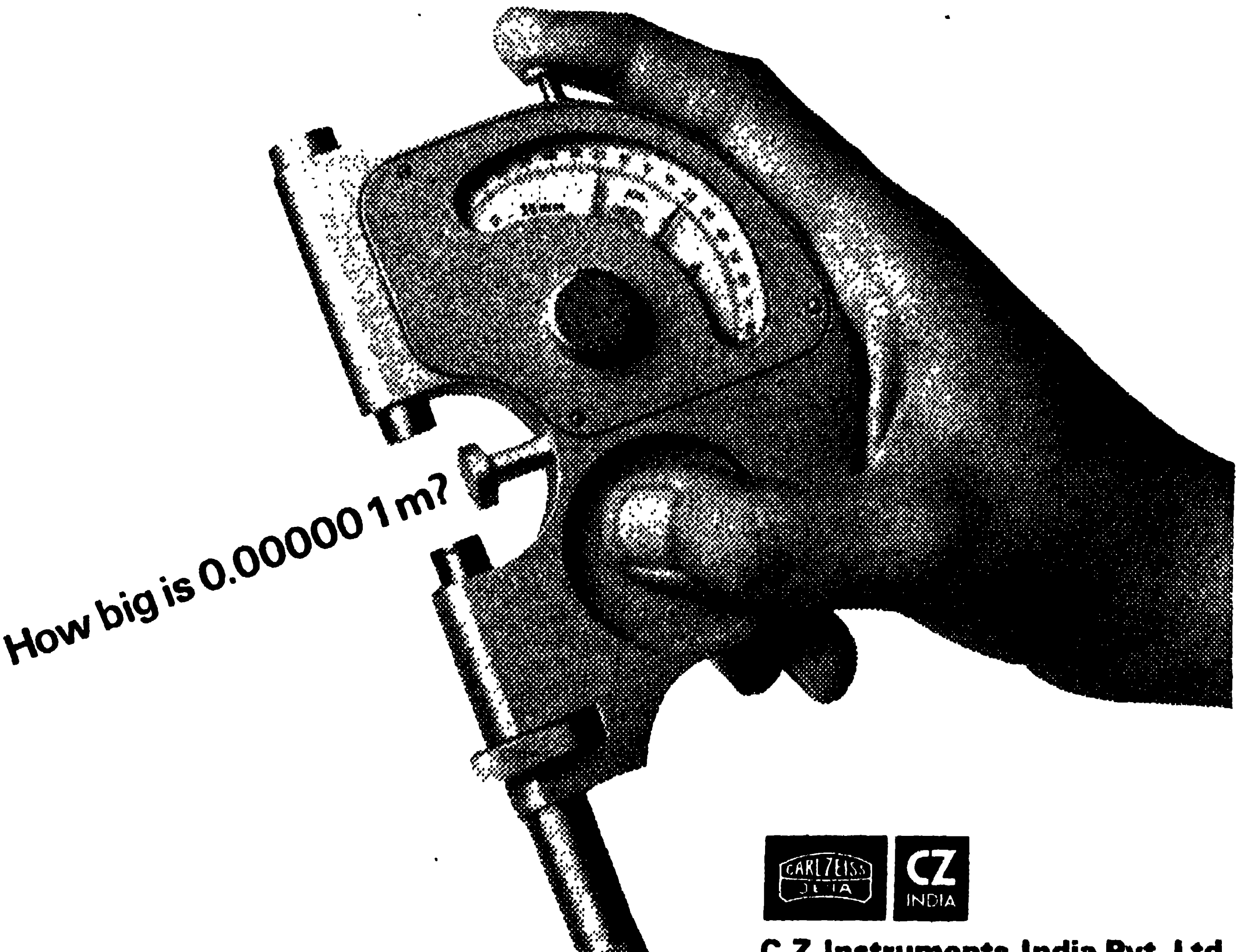

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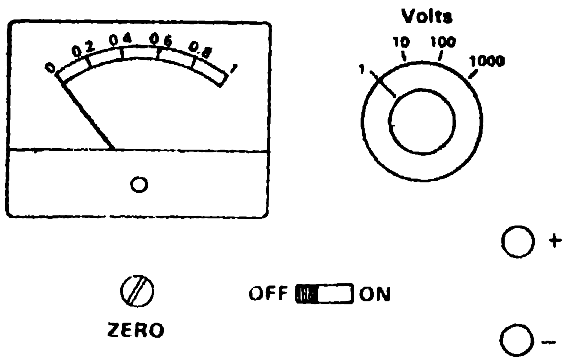
AC/DC FET Voltmeter



ORDINARY voltmeters cannot be used for measuring voltages of all the points in an electronic circuit because the current required for the deflection of the pointer is actually drawn from the circuit itself. This results in wrong indication of voltages and improper operation of the circuit. An electronic voltmeter is the only solution to these types of problems because they practically draw no current at all from the circuit under measurement.

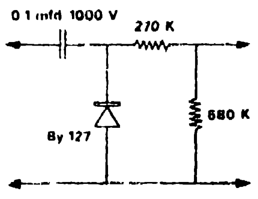
The operation of the field effect transistor (FET) is similar to that of a vacuum tube. Both have very high input impedance, i e in both the output current is determined by the input voltage rather than the input current (thus, both are called voltage-operated devices). On the other hand, ordinary transistors are basically current-operated devices because the output, i e the collector current, is determined by the input, i e the base current. Though this base current is very small as compared to the corresponding collector current, in some applications even that cannot be tolerated.

The circuit on the right hand side of the vertical line is the FET voltmeter for measuring DC voltages up to 1,000 volts.

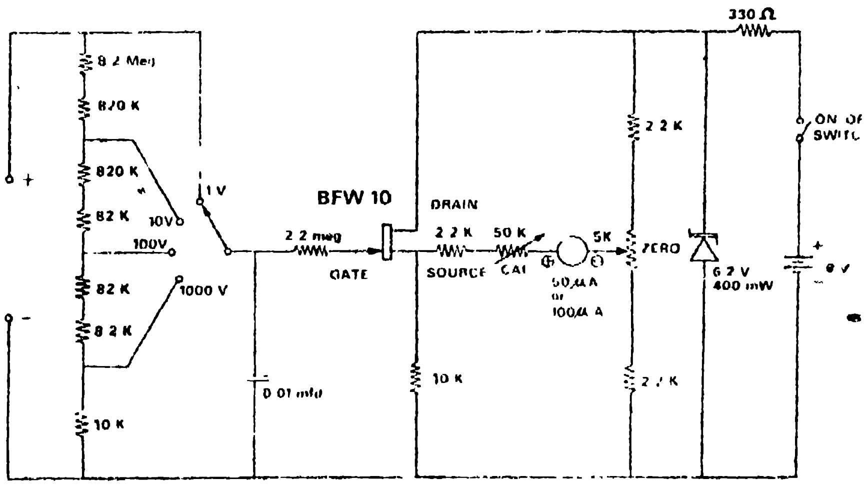
The 10 Meg ohm voltage divider is used for voltage range selection. The voltage under measurement is actually connected across the voltage divider. The part of the voltage obtained from the voltage divider is fed to the gate, i e the input terminal of FET. The source and drain terminals of the FET are connected as one arm of the Wheatstone bridge. Thus, the voltage fed to the gate produces the imbalance in the bridge. This imbalance is indicated by the microampere meter connected across the bridge.

While measuring AC voltages with this type of instrument, a special type of rectifier probe has to be utilised. The circuit diagram of this probe is shown on the left side of the vertical line. This probe actually converts the AC voltage fed to it in suitable DC voltage so that the FET voltmeter reads the r.m.s. value of the input voltage. This probe will work successfully for measuring radio frequency voltages up to about 1 megahertz, provided the circuit part of the probe is kept as close as possible to the measuring point, as shown in the diagram.

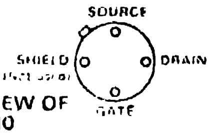
(Contd. on p. 65)



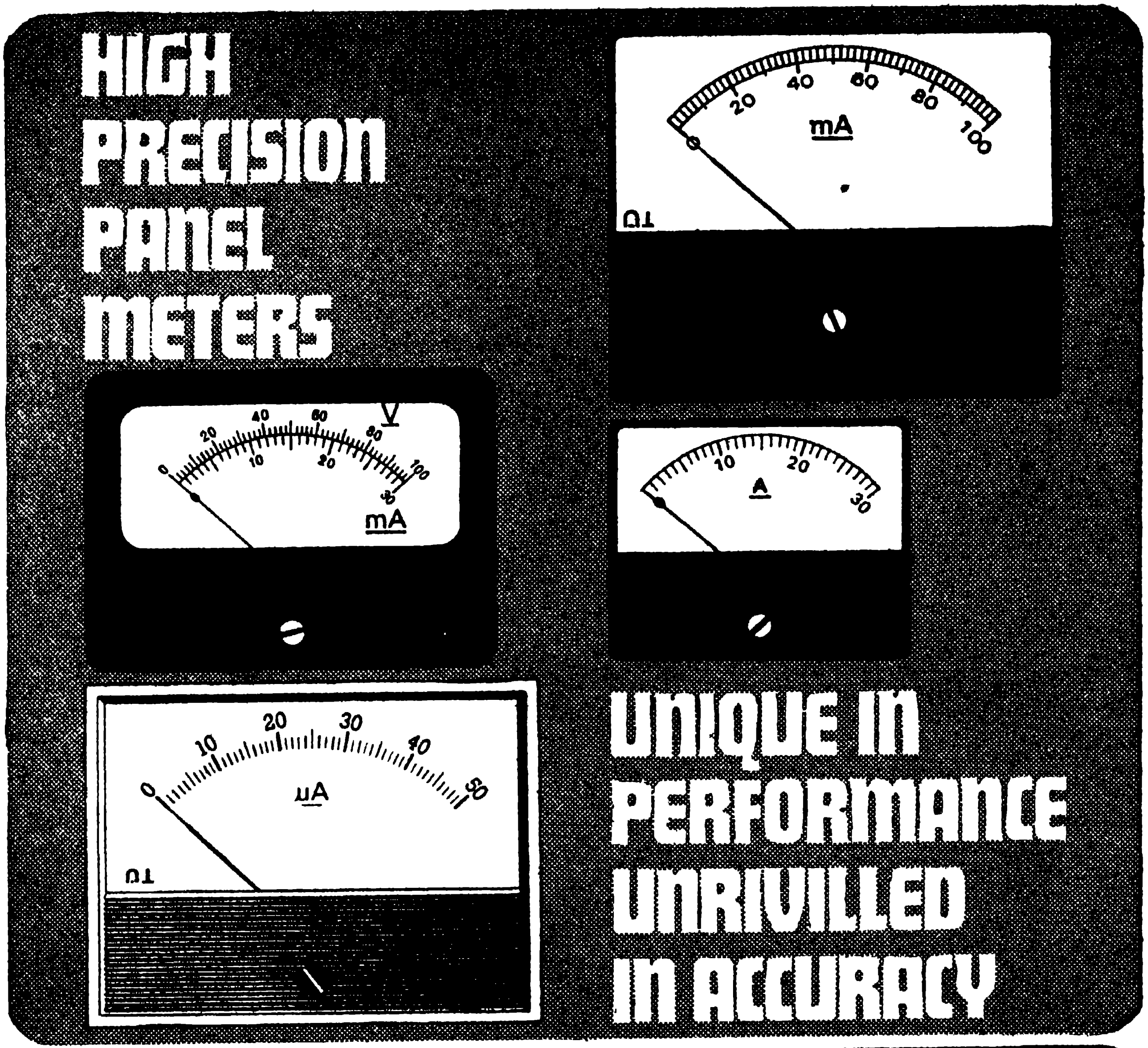
A. C.Rectifier Probe



FET VOLTMETER



BOTTOM VIEW OF BFW 10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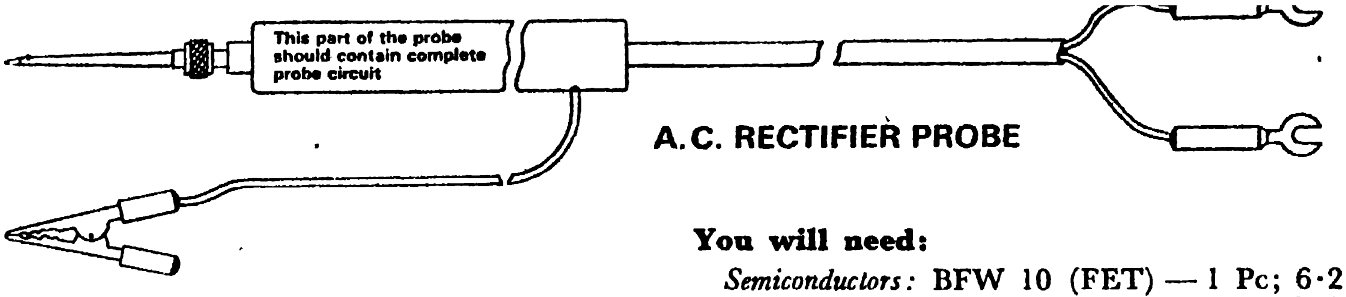

This part of the probe should contain complete probe circuit

A.C. RECTIFIER PROBE

(Contd. from p. 63)

When the circuit is wired, check it thoroughly and then follow the calibration procedure as described below:

Calibration

- *a.* Switch on the supply.
- *b.* Keep the voltage range selector on minimum voltage range, i c 1 V.
- *c.* Short the DC input terminals of the device.
- *d.* Adjust the zero potentiometer so that the meter reads zero.
- *e.* Connect an accurate 1 V. DC with proper polarity across the voltage divider.
- *f.* Adjust the calibration potentiometer such that the meter shows full-scale reading.

You will need:

Semiconductors: BFW 10 (FET) — 1 Pc; 6·2 V—400 mW (zener) — 1 Pc, BY 127 (rectifier) — 1 pc.

Meter: 50 microamps or 100 microamps — 1 Pc.

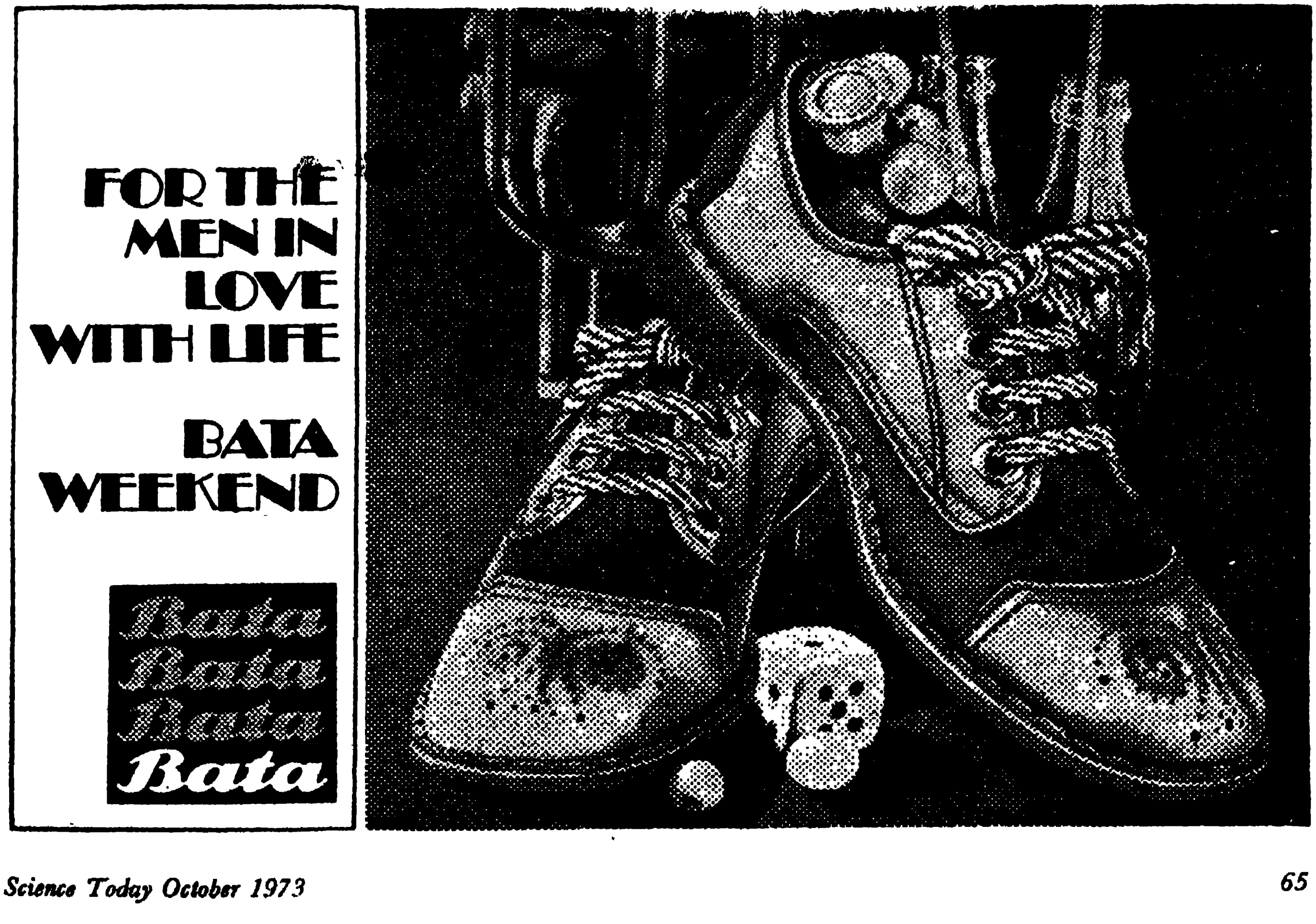
Resistors: (all half watt): 8·2 Meg — 1 Pc, 820 K — 2 pcs, 82 K — 2 pcs, 8·2 K — 1 pc, 10 K — 2 pcs, 2·2 M — 1 pc; 2·2 K — 3 pcs; 330 ohms — 1 pc; 270 K — 1 pc; 680 K — 1 pc.

Condensors: (Polyster or paper) 0·1 mfd 1,000 v — 1 pc, 0·01 mfd 400 v — 1 pc.

Potentiometers: 5 K — 1 pc, 50 K — 1 pc.

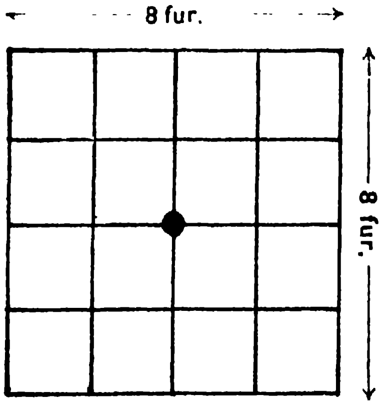
Misc.: Battery — 9 volts, Selector switch 1 pole 4 way, Terminals (red and black) — 1 pair, U clips (red and black) — 2 pairs, Crocodile clips (red and black) — 2 pairs, On/off switch — 1 pc, wires, solder, suitable enclosure, screws, etc.

Anil V. Borkar



brain teasers

MILK-SUPPLY PROBLEM: The plan of the streets of an industrial township with a milk dairy in its centre is as shown in the figure. Each street (indicated with lines) is two furlongs away from the adjacent one, laid out in the same directions. An adequate but minimal number of milk-booths are to be located at places convenient to milk-buyers who shouldn't walk more than two furlongs along the road in order to reach the nearest milk-booth or the dairy. What is the minimum number of milk-booths required? Show them in the figure and also the shortest route of the milk-truck which has to deliver supplies to the milk-booths. The truck cannot be backed on any of the streets.



Om P. Goyal

TROUSERS AND SHIRTS: I had got stitched for me some trousers and some more shirts. When I was taking delivery, I found that one-third of the trousers and one-half of the shirts were not up to my standards; perhaps they were stitched by apprentices, and I rejected them. That left me with the same number of shirts and trousers. The total number of garments ordered was a perfect square. If the rejected shirts were less than 15, how many garments were ordered by me?

FACTORY WORKING: There is a factory in Bombay, where the workers are paid according to the time they actually work. But there is one rule: one has to start (and also stop) the work at a time when the minutes are a multiple of the hour. When should one start and stop so that he gets the maximum wages with a 12-hour shift? Of course, he has to come to the factory when the clock strikes any hour of the day.

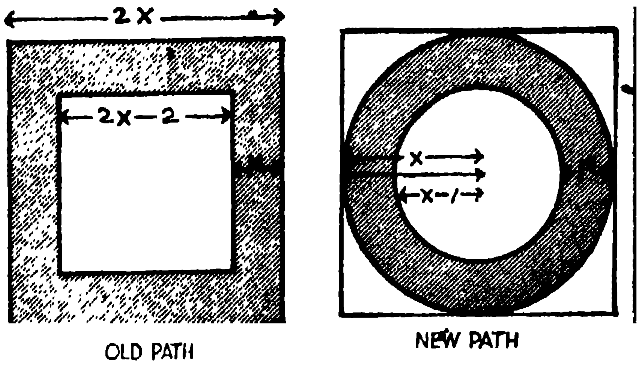
(*Solutions next month*)

V. A. Shenai

Solutions to last month's Brain Teasers:

Garden Path

The old and the new paths are shown below:



Let the side of the garden be $2x$ feet.

The area of the old path $= 2x \times 2x - (2x - 2)^2$ sq. ft.
$= 8x - 4$ sq. ft.

The area of the new path $= \pi x^2 - \pi (x - 1)^2$ sq. ft.
$= \pi (2x - 1)$ sq. ft.

There is a difference of 6 sq. ft. in these areas. Therefore,

$$8x - 4 = \pi (2x - 1) + 6$$

Solving this simple equation,
We get $x = 4$
The earlier effective gardening area is $(2x - 2)^2 = 36$ sq. ft.

Squares and Cubes

Sunila : 26 P = 25 + 1 = 27 − 1
Shobha : 37 P = 36 + 1 = 64 − 27

Mango Puzzle

Let a mangoes be purchased at b paise per mango. The total amount paid was $a \times b$ paise. Since $b = 3a$, b must be between 30 and 99 and a, between 10 and 33. Let us consider the values in sections. If a is between 10 and 19, b is between 30 and 57. Since b starts with the ending digit of a and if a begins with 1, it can only be 13, 14 or 15, making b equal to 39, 42 or 45, respectively. In all these cases a b is a three-digit figure (it has to be a four-digit figure). Hence a does not begin with 1. If it begins with 3, b begins with 9, making a, 39. But a cannot be more than 33. Therefore, the first digit of a is 2 and b is between 60 and 87 and starts with 6, 7, or 8, and a is 26, 27 or 28.

Now $3 \times 26 = 78$. If a is 26, b should be 78. This is not possible, since b should start with 6. If $a = 27$, $b = 81$. This is also not the answer, since b should start with 7. This leaves a to be 28 and b to be 84 which, in fact, starts with 8.

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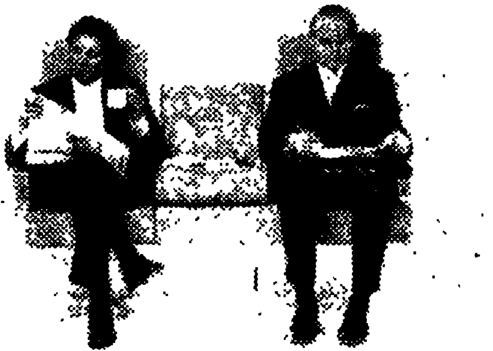

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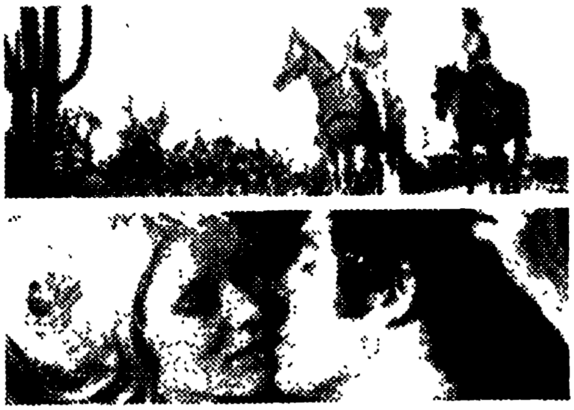

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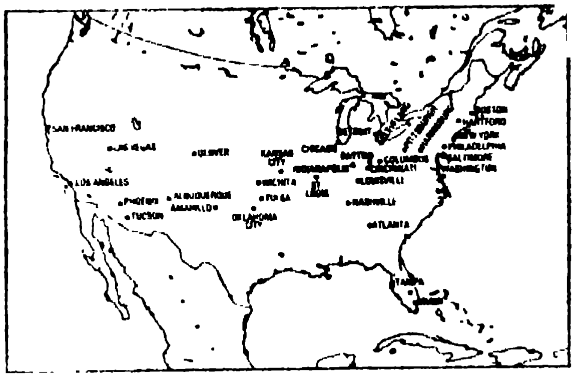

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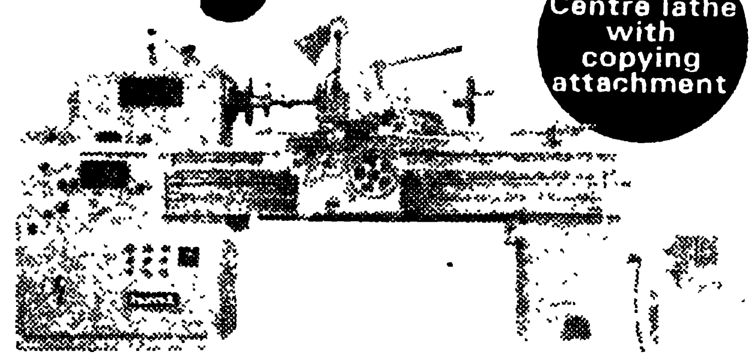

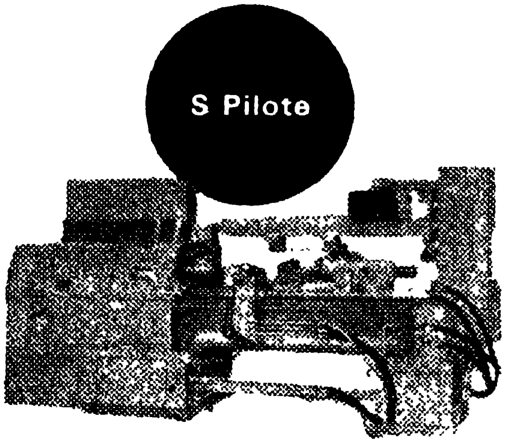

HMT has an answer for every copy-turning problem, every kind of profile, every volume of production and every budget.

Our range starts with centre lathes with copying attachment.

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If you are turning massive, complicated profiles - if you have a range and variety of profiles to be copy turned - if you need repetitive accuracy on high batch production — HMT S Pilote is the answer.

S Pilote accommodates lengths up to 1000 mm, gives sustained accuracy with fool-proof punched card programming for four cut cycles.

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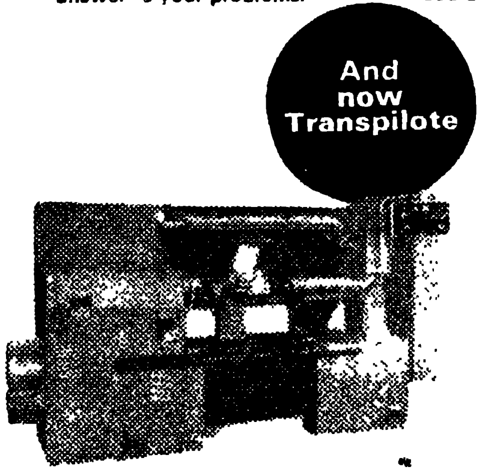

The HMT Transpilote is in between.

If you machine complex profiles and need repetitive accuracy in mass production—you don't need the massive capacity of the S Pilote and the profiles you copy turn are below 750 mm in length — then the HMT Transpilote, at 2/3 the cost of the S Pilote, is the machine for you. It takes 60% of the jobs the S Pilote takes.

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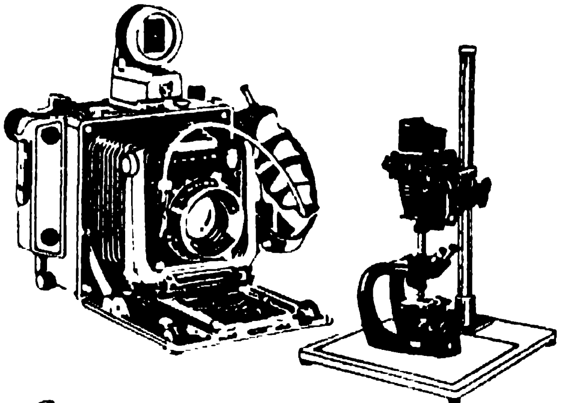

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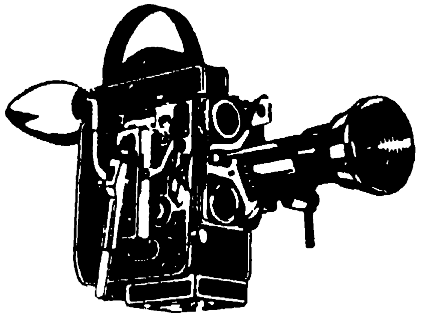

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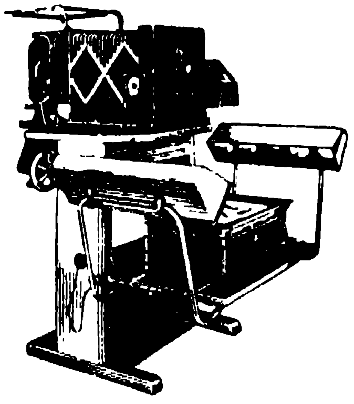

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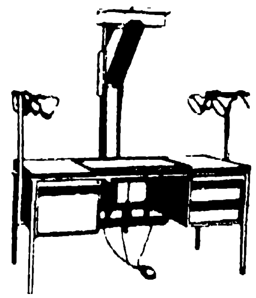

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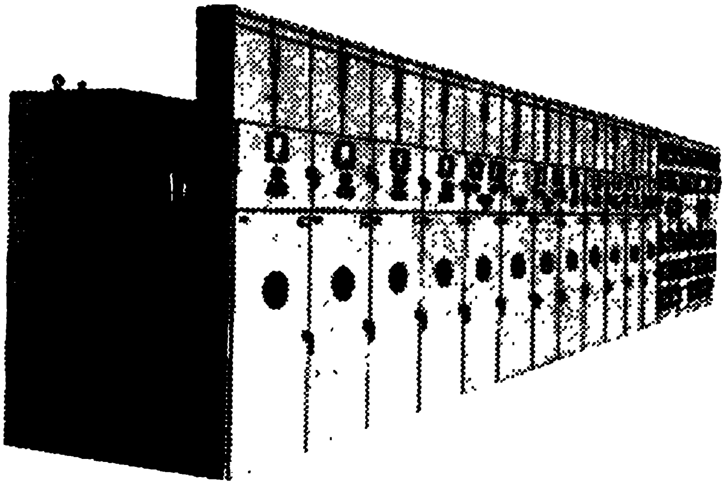

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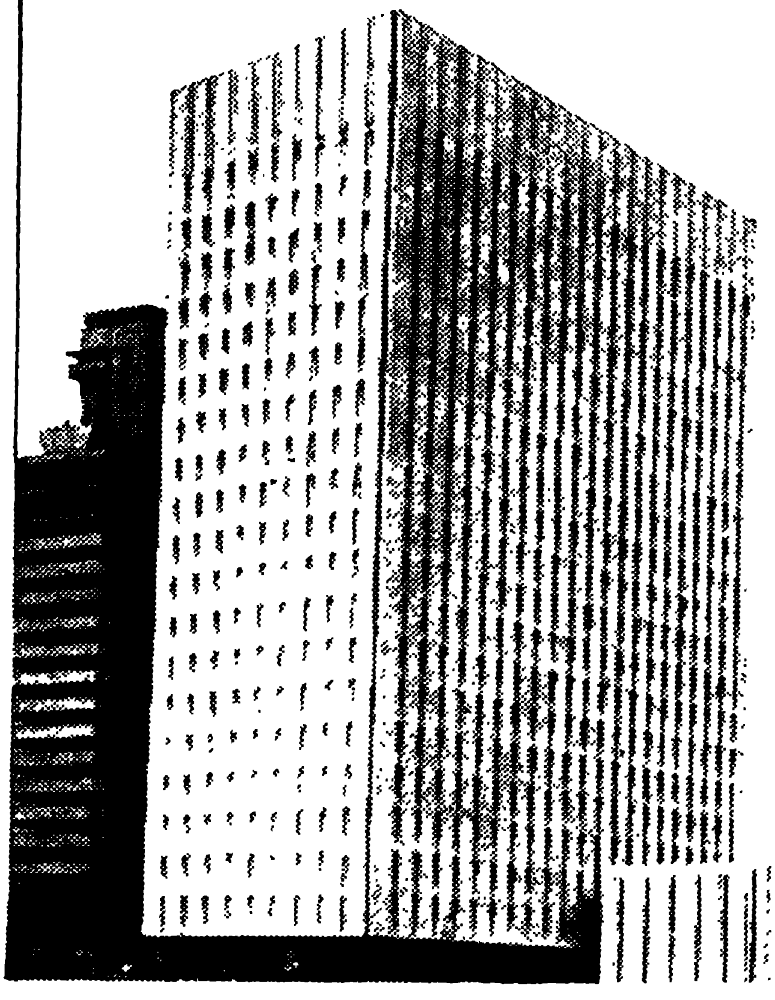

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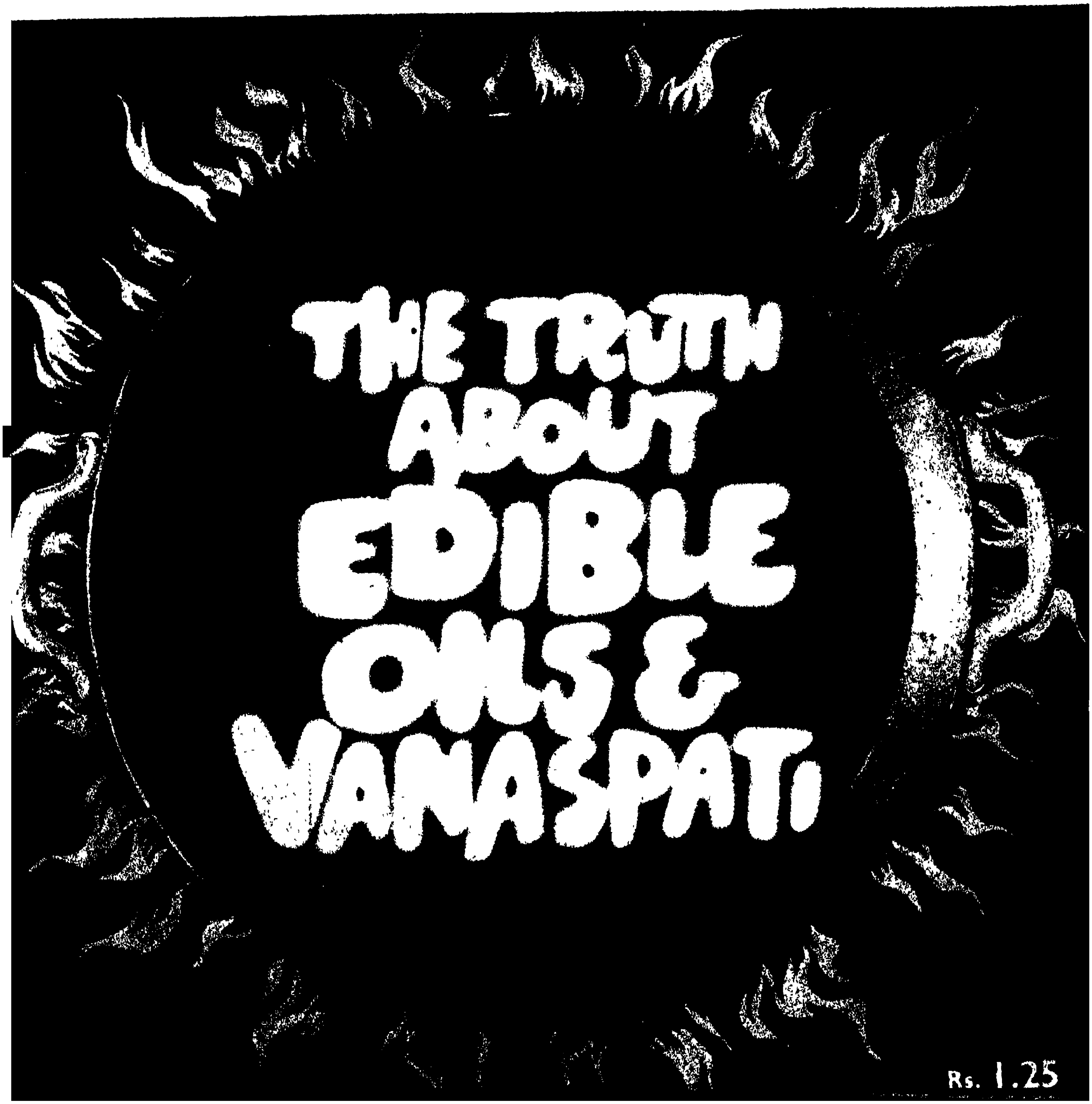

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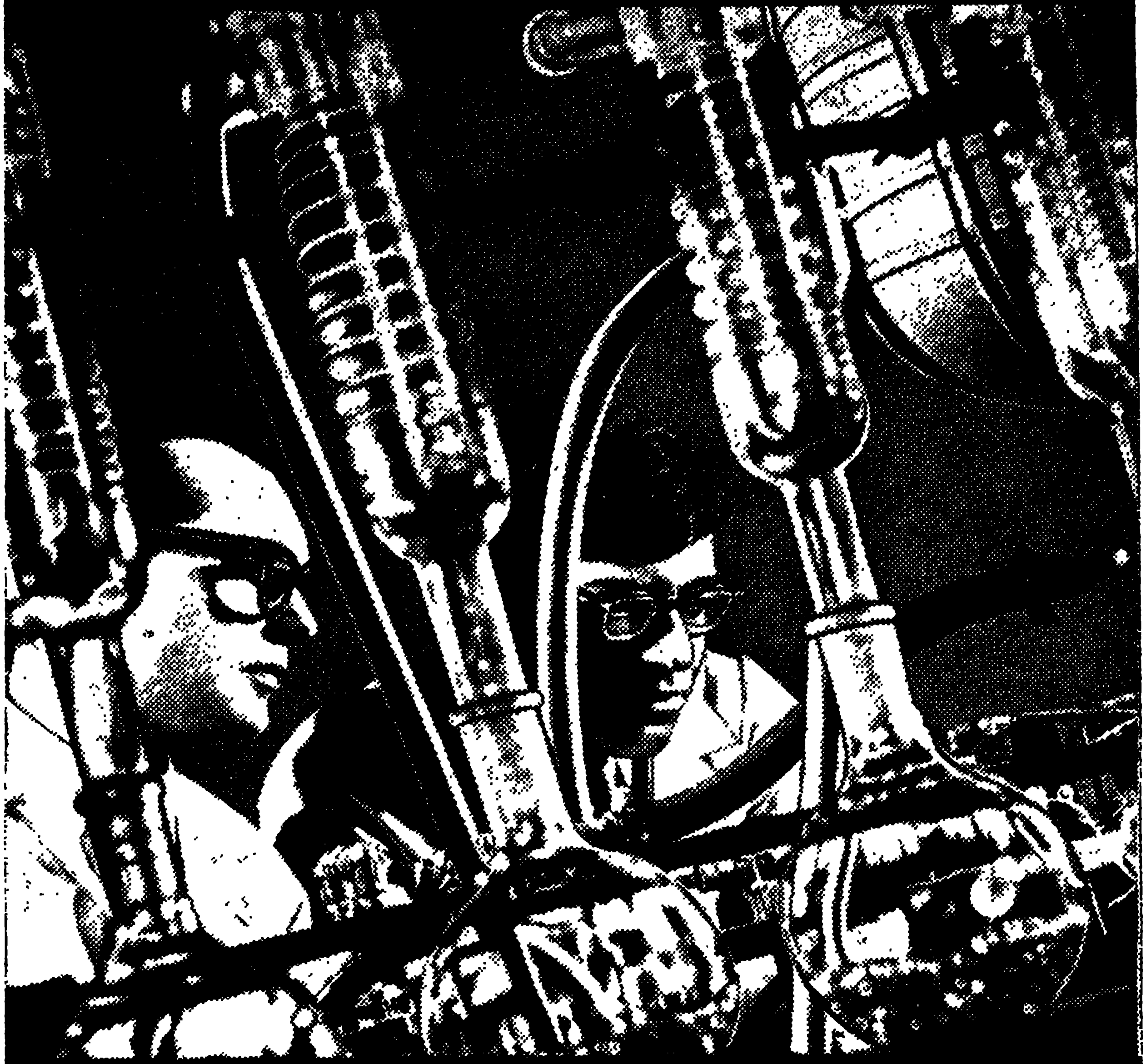

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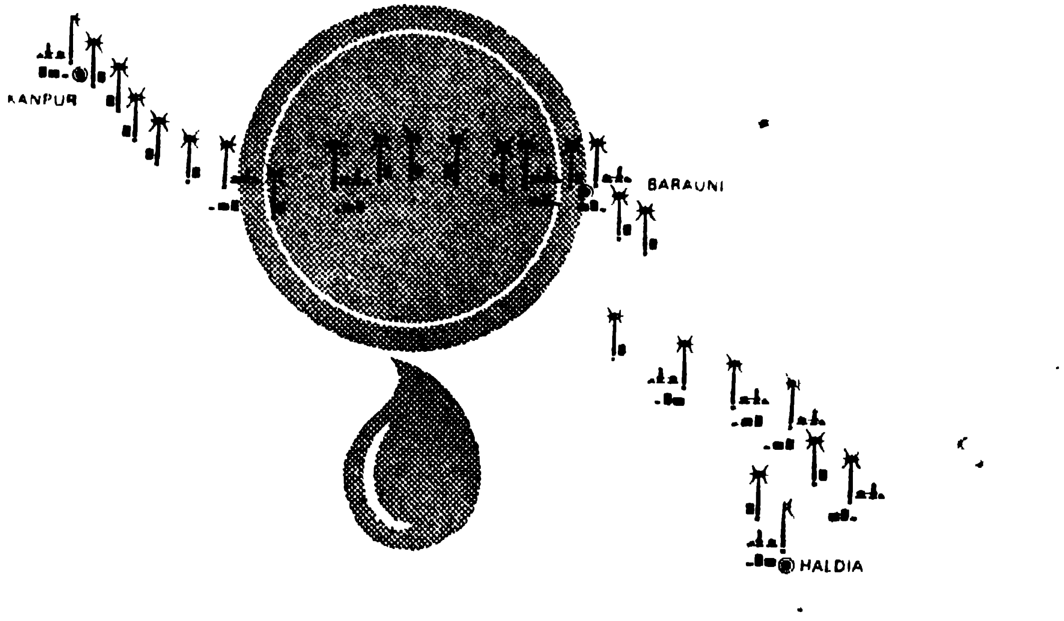

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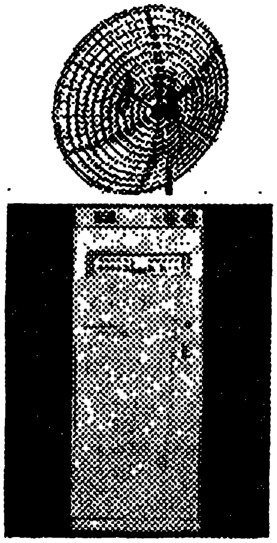

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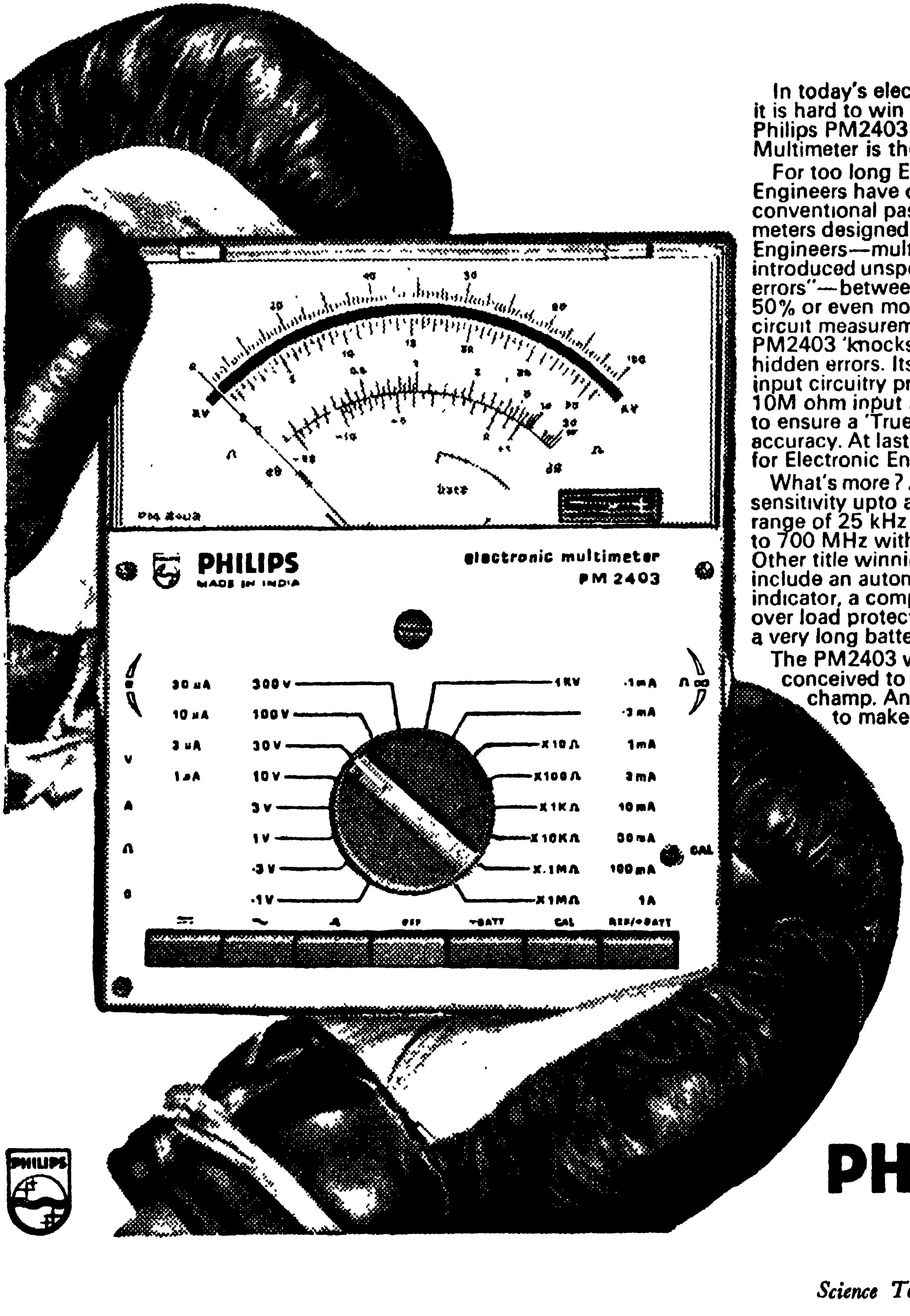

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SCIENCE TODAY

VOL. 8 NO. 5
November 1973

WHAT DO YOU KNOW ABOUT YOUR COOKING GAS?
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R. Narasimhan

The popular view that science is about the naively observed regularities of nature is somewhat simplistic. If one wants to know what are scientific theories theories of, the answer is, they are theories of experiments

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30 THE TRUTH ABOUT COOKING OILS & VANASPATI

K. A. Neelakantan, D. Rebello, K. T. Achaya & S. S. Rajan

The human body needs fats and we have learnt to ingest it in the form of cooking media derived from both animal and vegetable sources. For our large vegetarian population, animal fats are taboo. Though vegetable oils and vanaspati have done well till now, their acute shortage today has made us suddenly aware of their importance in our daily diet

- **WHY DO WE NEED FATS?**
- **WHERE DO THEY COME FROM?**
- **SOURCES OF VEGETABLE OILS**
- **HOW THE OILS ARE EXTRACTED AND REFINED**
- **THE CHEMISTRY OF FATTY ACIDS**
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G. K. Seth

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J. B. Mukherjee

Despite liberalised laws, two-thirds of all abortions done in India are done illegally by quacks. Many turn out to be fatal. Forensic medicine is now up against the criminal abortionist

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COVER
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SURENDR JHA

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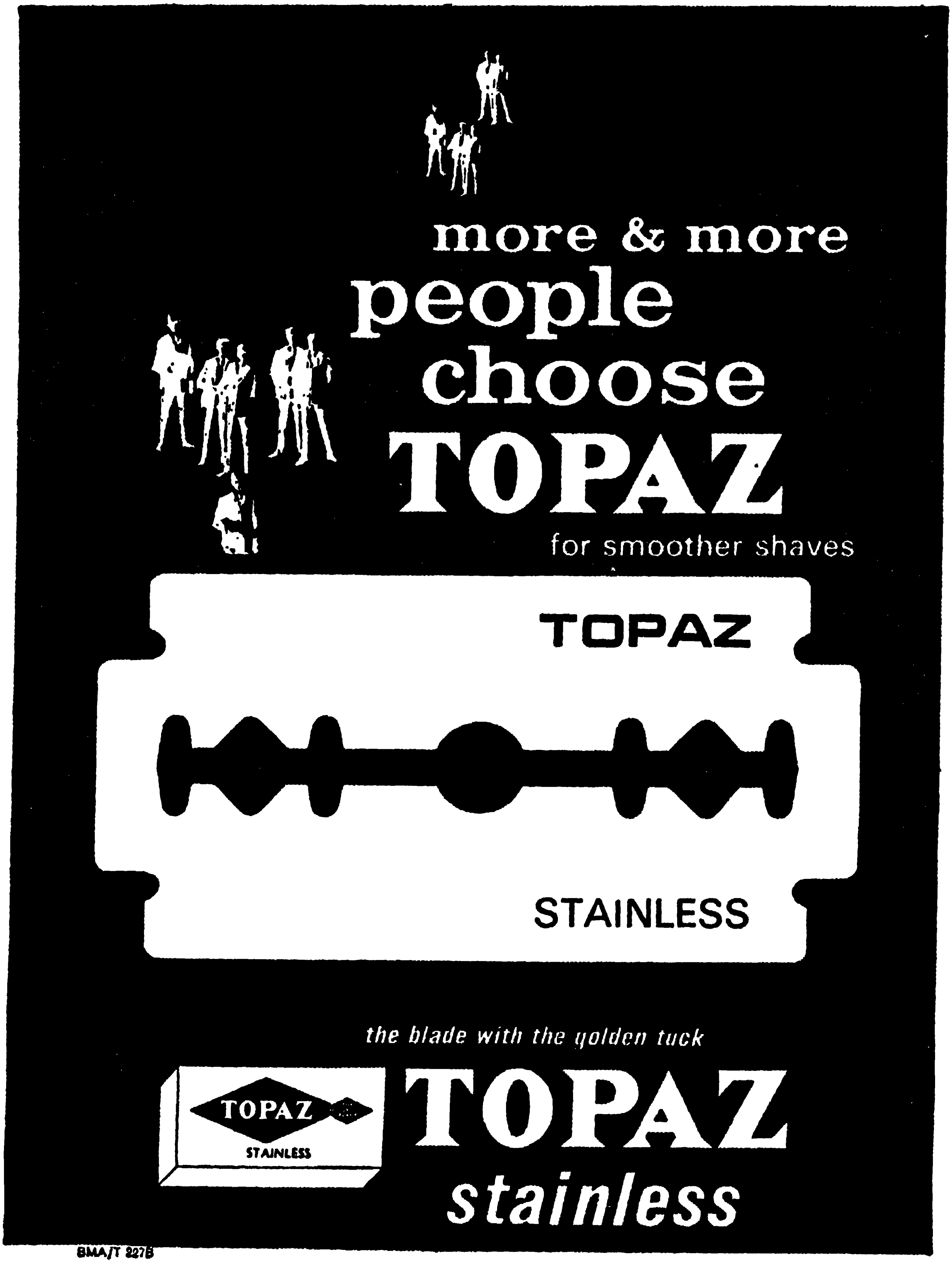

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letters

Growing mushrooms at home

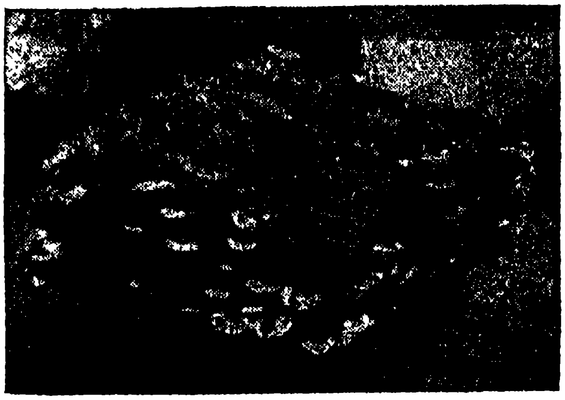
I HAVE read with interest the article on mushrooms by Sudhir Ghatnekar in your July issue. The Tamil Nadu Agricultural Department (Plant Pathology Wing) is one of the pioneers in growing Paddy Straw mushrooms. For 35 years now, the Department has been growing the mushrooms and distributing spawn. The Department now distributes about 400 to 1,000 bottles of spawn every year.

Paddy Straw mushroom contains 90 to 92 per cent water. The rest 8 to 10 per cent is rich in protein ; it contains mineral salts and traces of iron, copper, potassium and calcium. It is also rich in vitamin B and D and is entirely free of starch. It is, therefore, an ideal food for diabetics.

Paddy Straw mushroom can be easily grown at home. It grows exclusively on paddy straw. Hand-threshed paddy straw gives good results. The straw is arranged in 20 to 25 cm thick bundles, weighing 1·5 to 2 kg each. Thirty-two such bundles are required. The bundles are steeped in water for 12 hours and arranged in layers on a platform raised about 0·3 metre or a foot from the ground by placing bricks (to form the four corners of a 1·25-metre square) and by laying a deal wood plank over the bricks. Four bundles are placed side by side on the plank, with the thick end on the same side as shown in Fig. 1. Another four bundles are placed over this with their thick ends on the opposite side, so that the layer becomes uniformly thick (Fig. 2). This is the first layer. Three more layers are similarly formed with eight bundles each, and arranged as shown in Fig. 2. The bed is pressed hard with a flat plank and covered with transparent polythene (black or coloured polythene delays the growth).

The spawn bottle is now broken, and bits of spawn are placed 10 to 12 cms apart along the edges of the layer and 10 to 12 cms away from the margin (Fig. 3). Redgram dal (pigeon pea) powder, ground coarsely, is sprinkled over to feed the spawn. About 0·25 kg is required for a bed. Two bottles of spawn are required per bed. Each bottle costs Rs. 2·50 exclusive of freight.

Mushroom growth depends on the regulation of moisture. The bed should not be allowed to dry nor made to drip water. About eight litres of water may be required on the fourth day of spawning ; this is to be poured through a fine hose or a rose can from the top. A second watering (six litres) on the eighth day may be necessary, and a third watering on the 12th day with four litres may be sufficient. White pinheads will begin to appear about the sixth day. The full mushrooms will appear in 12 to 14 days and continue to grow for 3 to 4 days. The yield from a bed is 3 to 4 kg. The mushrooms can be picked in the full button stage when it is most delicious.



Paddy Straw mushrooms need diffused light and the beds should be protected from direct sunlight. An open verandah or a shed with a good roof is adequate. Mushroom growth will be poor when the temperature is below 24°C or 75°F (December to February in Tamil Nadu).

C. S. Krishnamurthy

ICAR scientist, Mushroom Project, Coimbatore

Fig. 1

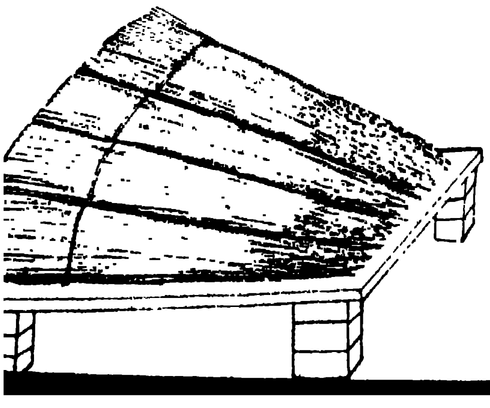


Fig. 2

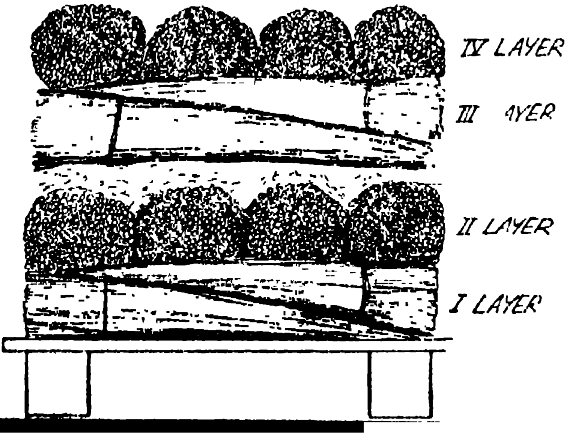
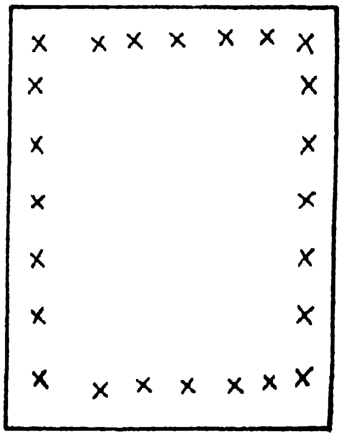


Fig. 3



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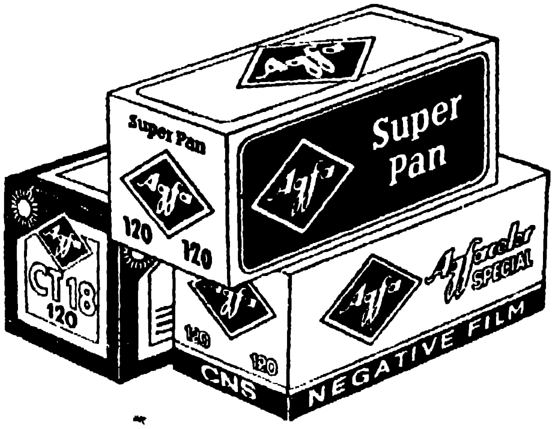

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letters...

Mushrooms . . .

I have received several enquiries from your readers about the places from where spawns could be obtained and about the titles of books on mushrooms.

Experiments on the cultivation of Paddy Straw mushrooms are being done at Regional Research Laboratory (CSIR), Jammu; National Botanical Gardens, Rana Pratap Marg, Lucknow; Agricultural College and Research Institute, Lawley Road, Coimbatore; and Indian Agricultural Research Institute, Pusa, New Delhi. For good quality spawn, it is desirable to start from pure cultures, which can be obtained from any of these places.

While Paddy Straw is a tropical mushroom, White Mushroom (*Agaricus bisporous*) normally grows in temperate climates. It is being grown in India on some private farms in Himachal Pradesh, in Srinagar and around Delhi. Pure cultures of White Mushroom may be obtained from the Himachal Agricultural Institute, Solan, Himachal Pradesh; or the Regional Research Laboratory (CSIR), Jammu.

Here are some books on mushrooms: *Mushrooms and Truffles* by Rolf Singer; *The Savory Wild Mushrooms* by Margaret McKenny; *Toadstools and Such* by Solveig Paulson Russell; *Mushrooms and Toadstools* by Moten Lange and F. Bayard Hora; and *The Mushroom Hunter's Field Guide* by Alexander H. Smith.

Sudhir Ghatnekar
Botany Department, Ramnarain Ruia College,
Bombay

"Is the Indian scientist well-paid?"

In a country where about half the population live below the poverty level, a discussion of the salaries of those who are already paid much above the poverty level may look odd. Again, in the lower levels of service, since the people are anyway getting much less than the need-based wages, a comparison between a peon and a jawan is profane. Even assuming that the jawan is superior to a peon and that he should be paid more, can anyone say that he is inferior to a director or a secretary?

Mr. Ray has claimed (July '73) that posts in technical organisations are given lower pay compared to similar designations in secretariats or headquarters sphere. Similar designations *alone* do not call for similar pay scales. Designations such as directors, managers and secretaries mean different things at different places — both in the magnitude and nature of work involved. Mr. Ray's argument that the pay scales for Directors of Botanical and Zoological Surveys are significantly lower on the premise that the Director is *like* a Director-General is arbitrary; if his contention is true, the post should be upgraded as Director-General (in which case there would also be opportunities for more people in the lower grades to become directors in several zonal and field units).

Regarding the salaries and promotion opportunities for scientists, Mr. Ray has raised some relevant points. Not only do the scientists have relatively slow upward career movement, but even at the start, a research scientist usually gets a meagre amount of Rs. 250 to Rs. 350 (in some cases about Rs. 450) while his counterparts in administration or banking start with more than Rs. 700 with a secure job and career prospects. The research worker has to struggle with this paltry stipend for about 5 years before he gets a PhD. Even then he is not assured of a reasonably remunerative job. Is this conducive to good standards in scientific research?

Dr. V. S. Venkatavaradan
Geophysics, TIFR, Bombay

"Lessons in shaving"

Dr. T. A. Lincoln's advice ("Science Shapes Life", SCIENCE TODAY, August 1973) is to delay shaving at least for an hour after you wake up and to use salt water instead of hot water. But the one hour wait few can afford on a working day, and some may be allergic to salt water (it may cause irritation of the facial skin, especially the chin).

There is a simpler method: shave immediately after a morning bath. The bath not only removes sebum and the greasy and the non-greasy creams and lotions used during the day or night, but also promotes the bristling of hairs. And a hot bath is more effective than a cold one.

M. M. Mangrulkar
Assistant Director, Technical Education,
Bhopal

"Who is killing India's future?"

Prof. Ahmad's article (SCIENCE TODAY, August 1973) was indeed thought-provoking for us, the common people, who really don't know what is happening behind the scenes. I only hope that this well-timed article (for it is never too late!) will serve as an eye-opener for the Planning Ministry.

Latafat Hussain
St. John's School, Varanasi

True, as Dr. Ahmad says, minerals do not grow like trees and there is no replacement for minerals, but by the year 2073 or 2173, some other substitute will have been discovered or invented! For, by then, mankind will be more civilised. I disagree with Einstein's statement that within a century man will return to the Stone Age.

A. Radhakrishnan
Bombay

science shapes life

Some truth in palmistry?

Certainly it is not possible to tell if your progeny will get wealth and fame. But the fingertips of women can point to some rare future diseases in their progeny. And, this is not traditional palmistry.

Females have two X chromosomes. The extra X can cause biological problems, so one of these is switched off soon after the embryonic tissues have differentiated. Consequently, females are genetic mosaics. This was deduced by Mary Lyon at Oxford. She carried out her studies on the basis of genes determining coat colour, located on the X chromosomes of mice. However, the Lyon hypothesis could not be tested on women.

Now two German scientists, E. Passarge and Elisabeth Fries, have extended the hypothesis to women too. They studied the fingertips of seven women. Each of them had at least one child afflicted with a rare X-linked genetic defect — their skins failed to produce sweat glands. The mothers, however, had adequate sweat glands because of their other X chromosome.

According to the Lyon hypothesis, such women's skin should show patches lacking in sweat glands. When the fingertips of the seven German women were magnified 16 times, the typical mosaic patchiness was easily discernible.

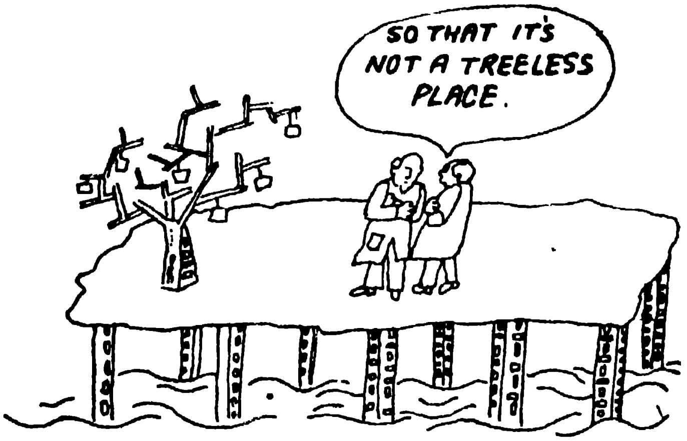
The hunger nerve

If it's cut, you won't feel hungry at all. By the way, what is hunger? An empty stomach? Fall in the level of blood glucose? The question has been nagging scientists for a long time. Till recently it was thought that when blood sugar level dropped, the brain switched on the hunger sensation. But now studies have shown that the hunger switch is not in the brain but in the liver. It is the liver which intimates the brain.

Three American psychologists, Donald Novin, Dennis Vanderweele and Milan Rezek, suspected that the vagus nerve was the hunger message transmitter. Working on rabbits, they cut the nerve and immediately lowered the blood sugar level by introducing 2-deoxy-dextroglucose into the blood supply to the liver. In control rabbits, the glucose blocking chemical produced an immediate effect — the rabbits started eating within quarter of an hour. In other rabbits, the compound was introduced into the neck vein. These animals and the rabbits with cut vagus nerve took more than an hour to start eating. Novin and his colleagues conclude that the nerve is the express hunger signal transmitter from the liver to the brain. But since the animals react even after the vagus nerve is cut, it means there are other glucose receptors in the brain too.

Steel island

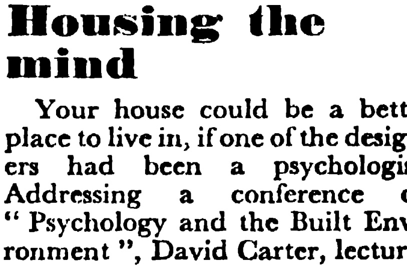
In a few years from now, an island made of steel is to be set up north-west of the Island of Heligoland, off the German coast in the North Sea. Erected at a depth of 100 metres, the artificial island measuring several hundred square metres, will be supported on strong steel-tube legs. The steel platform will be used by scientists for testing oceanographic measuring instruments. The platform will also be used as look-out for oncoming high tides.


SO THAT IT'S NOT A TREELESS PLACE.

Housing the mind

Your house could be a better place to live in, if one of the designers had been a psychologist. Addressing a conference on "Psychology and the Built Environment", David Carter, lecturer in psychology, Surrey University, UK, said that buildings could be made more efficient and pleasant with a psychologist on the planning team. And not just psychologists; people from other fields — such as cleaners — could also pool their information to make better buildings.

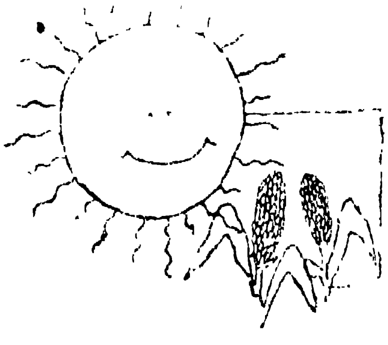
Carter carried out a series of studies on school buildings. He found that many of the architects' assumptions of how the place



would be used would not have tallied with a psychologist's idea. Carter was asked for his opinion on one of the most successful children's hospitals. The architects had provided play places for children to play in and for mothers to live in when necessary. But according to Carter, it still had a long way to go to make allowances for the psychological understanding of children. The design showed that the architects had assumed children of all ages to use the building in the same way. No outdoor play spaces had been provided, and for children, particularly the young, outdoor play is very important. Any psychologist, says Carter, would have pointed it out immediately.

Light increases yield

It's an old Russian practice to expose seeds to sunlight before sowing. However, it is only recently that scientists have started investigating the effectiveness of this method. Prof. Alexander Shakhov of the Institute of Plant Physiology, USSR Academy of Sciences, Moscow, exposed seeds of the same plant to sunlight. Some seeds were exposed to continuous radiation, while others were exposed to pulsed radiation.



It was found that prolonged radiation — for more than an hour — had adverse effect on the seeds. Pulsed radiation of the same dose rejuvenated the seeds. Other studies at the Institute reveal that light affects not only the green leaves, but the entire membrane system of plant cells.

Almost all seeds improved with the treatment. Cotton yielded more crop and longer fibres. Potato harvest went up too; the starch content increased and the susceptibility to disease was lowered. Tomato yield went up by nearly 25 per cent. Beet yielded more sugar; wheat and soyabean increased in protein content. The irradiated "photo" wheat is also better than its famous parent — the Besostaya I wheat — in protein and gluten content and has heavier grains per ear. It can also withstand frost better.

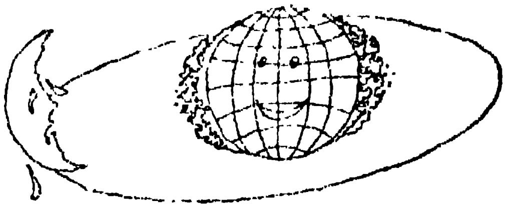
Maybe sunbathing could make a greener revolution!

Moon tides

The Moon is devoid of water, but it isn't free of tide effects. The proximity of the Earth at perigee leaves it quaking.

The moonquakes supply 90 per cent of the total energy released by all lunar events observed so far. According to Professor Rudolf Meissner and Joachim Voss of Kiel University, West Germany, the focus of the quakes is in the region of the Alphonsus crater.

Study of Moon seismograms and computational analyses show that perigee quakes occur near the Mare Nubium in which the Alphonsus crater is situated. Flashes of light are observed in the Alphonsus crater region; this is caused by the escape of gases from the lower strata of the crust. The flashes are more frequent when the Moon is close to the Earth. This could mean moonquakes are explosions triggered by the tidal attraction of the Earth.



Professor Meissner found similarities between the moonquake seismograms and volcanic eruptions at Hawaii, USA. He concludes: gas volcanism must be the cause of most of the important types of lunar quakes.

Siberian black-hole!

In 1908, a huge meteor hit the Earth in Siberia, and several square kilometres of forests were

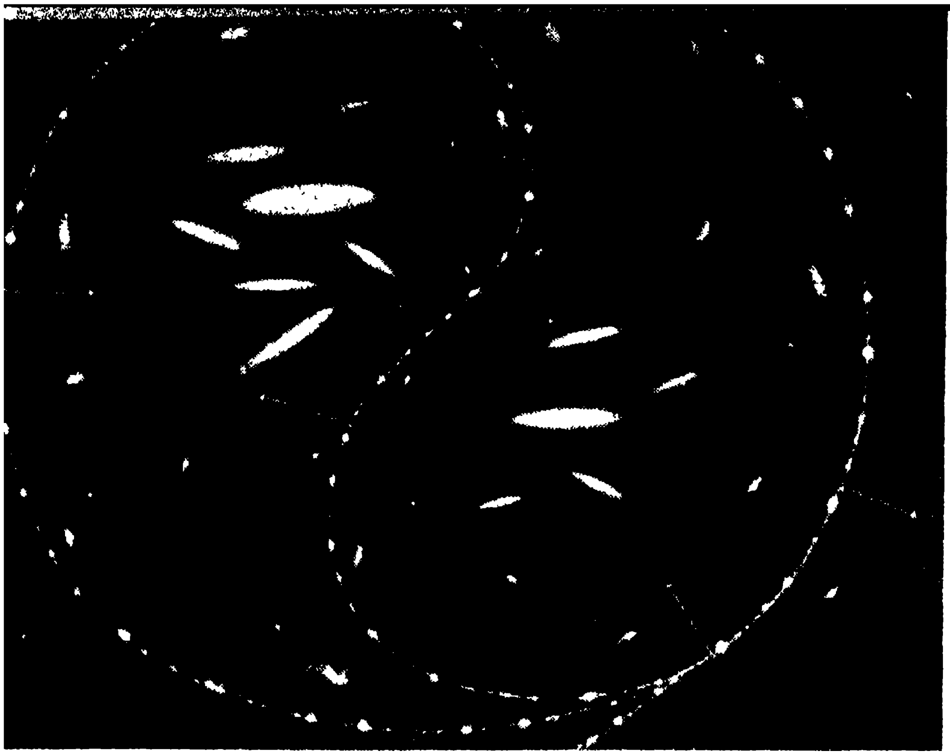
North Ireland's walking bombs!

Wash-n-wear, crease-resistant fabrics produce a high voltage of electricity on the wearer. If the climate is dry, the build-up is greater. The hazard has recently surfaced in Northern Ireland.

While many of the experienced terrorists of the IRA are behind bars, the inexpert amateurs are becoming walking bombs themselves. They parade in modern synthetic garb, with a bomb or two stowed away in their clothes. Their homemade explosives are prepared from sodium chlorate — a weed-killer — with sugar, or a fertiliser containing ammonium nitrate mixed with diesel oil. And the bombs often blow up before the thrower can throw. Not all the home bombs are faulty, though.

The British Army's explosives experts blame the clothes. They claim that a charge of 10,000 volts per sq cm can be built up by these synthetic fabrics. Though the current is negligible, the spark it causes is hot and can leap across considerable gaps.

The same problem occurs while transporting bombs by cars. The rubber wheels are good insulators. The static voltage developed by the synthetics in the car upholstery build up. That is why the hijacked vehicles too blow up.



Meet antimatter

But shake hands only if you too are made of antimatter. Or, else, you would disappear. Matter and antimatter annihilate each other when they meet, liberating a tremendous amount of energy. At the point of touch, their substance vanishes in bursts of radiation. This is shown in the picture by arrows.

Does antimatter exist in the free state in the universe? Space studies by Apollo astronauts and unmanned spacecraft show a strong positive evidence. The mirror-image worlds do exist. Will we ever come face to face with them ? From the measurements of cosmic radiations, scientists feel the antimatter-matter meeting must be taking place pretty far away.

destroyed. But, even to this day, no impact crater or meteorite remains of the Tungus have been found. Several explanations for this have come up from time to time.

Now two US scientists, Drs. A. A. Jackson and Michael Ryan of the University of Texas at Austin, USA, say that the meteorite was in fact a black hole, with the mass of an asteroid but only a few angstroms in diameter. Its velocity, they say, was greater than the Earth's escape velocity and hence, it passed right through our planet and came out in the North Atlantic, somewhere between 40-50°N and 30-40°W. If it didn't pass through — well! that would have been Doom's Day!

According to their calculations, the shock wave passing through the atmosphere would produce temperatures up to 10^6°K and a blue plasma. Eye witnesses had described the passage of the meteorite as a bright blue tube. Also, the temperature at the heart of the affected area might well have reached the estimated temperatures.

Flood warning system

The water level in the river rises. But the township stays put thinking it will abate soon. However, instances of miscalculation are numerous. The fact that so many lives are lost in floods calls for an efficient warning system.

The US National Weather Service, a component of the US Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), has developed a flash-flood warning system.

The warning system consists of an automatic water level sensor — an enclosed floating device which is lifted by the rising water. The sensor can be attached to any support, like a bridge, upstream in the river. When lifted to the danger level it transmits an electrical signal to an intermediate station. From here the warning can be relayed to all relevant areas.

The advance intimation gives about two to four hours for evacuation and traffic diversion.

Infertility a disease?

May be, in some men at least, say Swedish bacteriologists Hakan Gnarpe and Jan Friberg. Male infertility is a complex problem and has several etiological factors, both physical and psychological. The Swedish scientists' discovery adds another.

The bacterium suspected as one of the causes of male infertility is T-mycoplasma. This very bacterium was suspected of causing spontaneous abortions and stillbirths. Gnarpe and Friberg isolated the bacterium in the semen of men with unexplained infertility. These men were treated with antibiotics. After this, the wives of 30 per cent of these men became pregnant. Scanning electron micrographs of the semens showed that the bacteria actually attached themselves to the male generative cells.

Surgery to combat senility

It creeps in with old age and there has hardly been any treatment for forgetfulness till now. Recently, neurosurgeon Henry A. Shenkin and his colleagues evolved a simple surgical method to cure at least one type of senility.

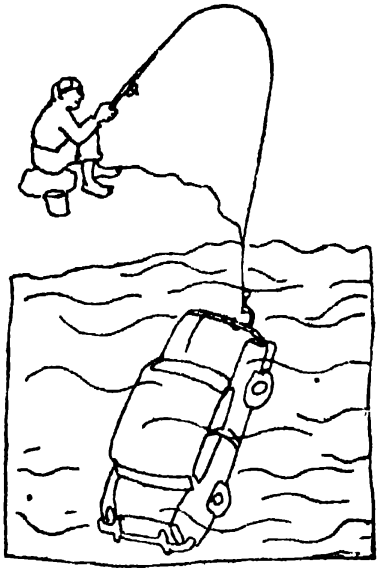
This type of senility is caused by the enlargement of brain cavities, called vesicles, by accumulation of fluid. At the Episcopal Hospital at Philadelphia, USA, Dr. Shenkin's team follows this procedure: they diagnose a patient for enlarged cavities in the brain. For this, the contents of the vesicles are withdrawn, and air is pumped in. The amount of air shows enlargement, if any. If the vesicles are enlarged, a tube is inserted into the brain and connected to the abdominal cavity through the neck and the trunk. The fluid is then drained off.

The Philadelphia team has treated 28 such patients, and 18 have recovered from senility.

Old cars make homes for fish

And also yield valuable exhaust filters. In Hawaii, old cars have been regularly dumped into the sea to create artificial reefs. The idea was to increase the fish population.

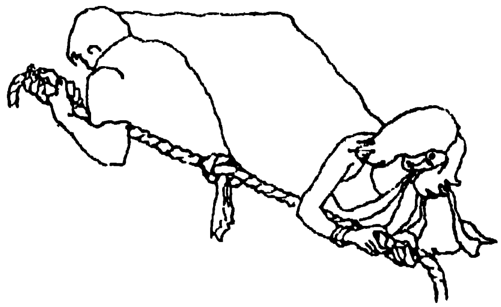
One day, it was noticed that the car bodies were being coated with a whitish deposit: manganese nodules and some platinum too. The manganese deposited in shallow waters was found useful to catalyse toxic exhaust gases. The deep sea nodules were not found useful. The precious platinum helps to rid the exhausts of carbon monoxide, nitrogen oxides and unburnt hydrocarbons. By modifying the old cars and treating them, University of Hawaii scientists hope to manipulate the crust. By passing mild electric currents the quantity too could be increased.



Battle of sexes—all in the mind?

Why is it that men and women fail to understand one another? They could, if one of them reversed his or her thinking procedure, say Phoebe Crammer and Jane Bryson of Williams College, Massachusetts, USA. Reporting in the *Developmental Psychology*, Crammer and Bryson state that the thinking processes are exactly opposite. Previous work has shown that women's fantasies differ from men's not only in content, but also in constitution. Men tend to start off with positive events and end up with negative ones; in women, deprivation is followed by enhancement. Is the female mind an improvement on the male ?

The two psychologists investigated the fantasy patterns in children too. The children were divided into two groups. One group comprised the nursery, and the other, first-graders. Given four pictures, they were asked to invent stories. Among the older children, there was a marked difference between the male and female minds. In the younger group, however, there was very little difference — both sexes followed the male pattern.



Shun the gas-light

The gas-mantle light, to be precise. The mantle is coated with a mixture of salts of thorium, beryllium, aluminium, silicon and cerium. When heated to incandescence, the high temperature volatalises the salts and they get airborne. Result: metal poisoning by inhalation.

Kyle Griggs of Lawrence Livermore Laboratory, University of California, Livermore, USA, found that beryllium emitted by the mantles manufactured in the USA went beyond the safety margin. Each fresh mantle, he calculated, contains 600 micrograms (μg) of beryllium. On lighting the mantle, two-thirds of it vaporises in the first quarter hour. Acute beryllium poisoning causes chilling fever, painful coughs and fluid accumulation in the lungs — similar to poisoning by irritating gases like chlorine. Chronic poisoning or berylliosis — an occupational hazard — causes oedema in the lungs called granuloma. Delayed poisoning may stretch from six months to three years; in rare cases even up to 15 years.

While lighting a gas-mantle lantern, one keeps one's face close to it. The lighting process takes about two minutes. The acute form of the disease could result even from a single exposure.

There are dangers from other toxic metal vapours too. The thorium used may contain radioactive thorium which gives out 300,000 alpha particles a minute. And even if the metal itself is not toxic, its daughter elements may be dangerous.

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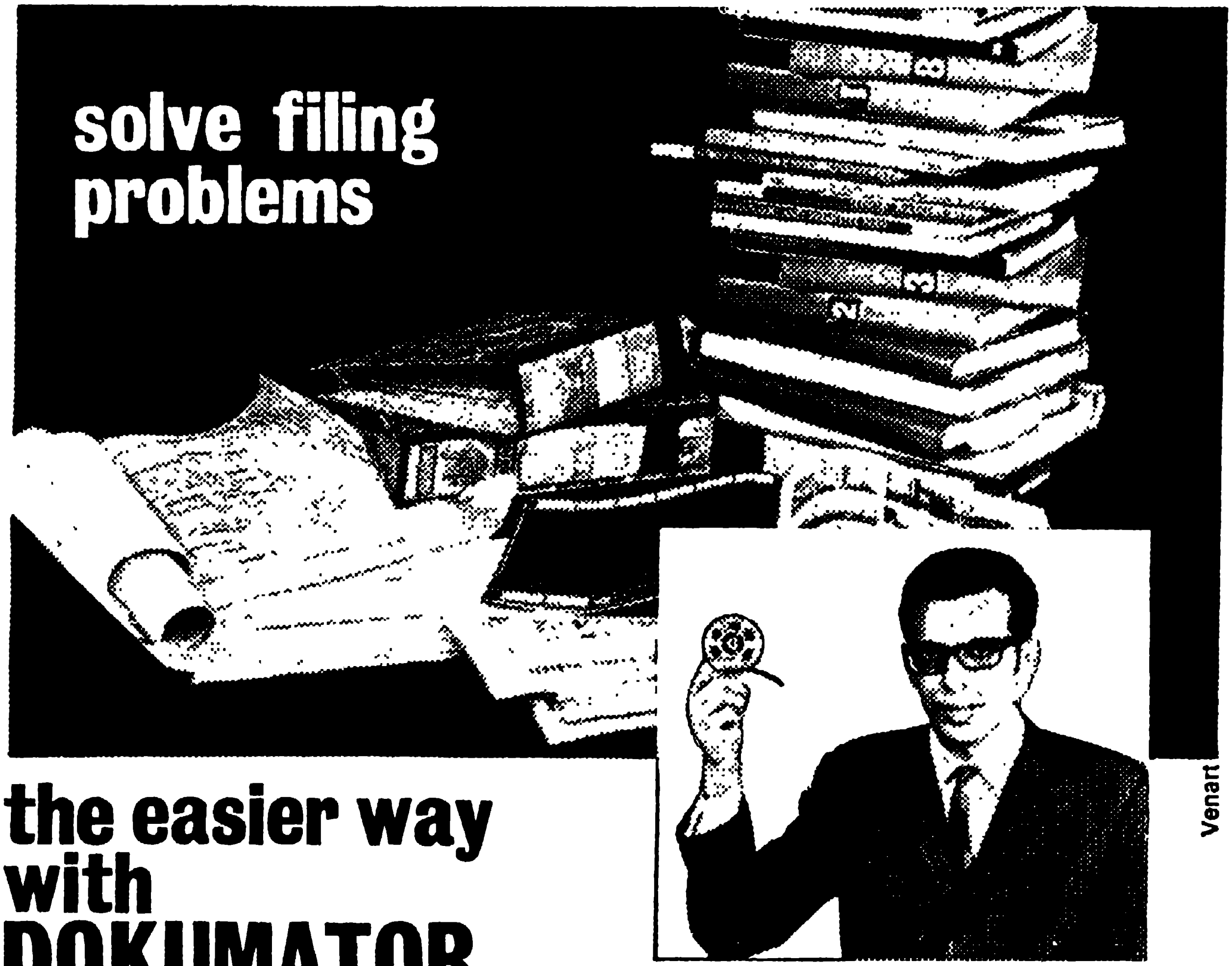

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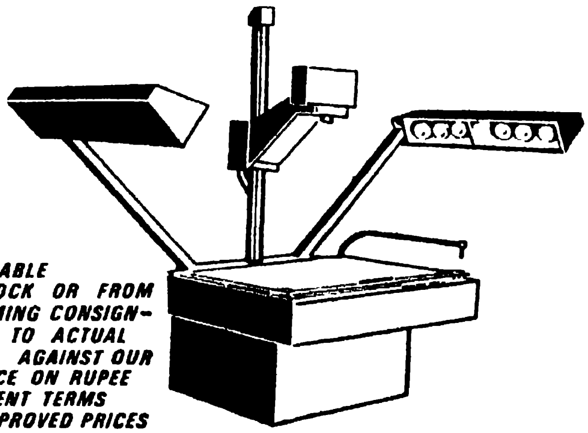

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WHAT IS SCIENCE REALLY ABOUT?

The popular view that science is about the naively observed regularities of nature is somewhat simplistic. Uniformities and regularities relate only to experimental situations . . .

It is the fact that situations of the open-ended world approximate more or less the situations of an experimentally controlled world that gives rise to the naively observed regularities of the world. If we wish to, we could look upon this as a happy accident. Science as an organised activity might not have got started at all but for this feature of the world . . .

R. NARASIMHAN

EINSTEIN, in his obituary article on Ernst Mach, wrote: " Nobody who devotes himself to science from reasons other than superficial ones, like ambition, money-making, or the pleasure of brain-sport, can neglect the questions: what are the aims of science, how far are its general results true, what is essential, and what is based on accidental features of development? " Einstein was making these remarks from a philosophical point of view. But to us, in countries like India, understanding the nature of science and scientific activity is an urgent necessity for very much more mundane reasons.

Many of us, scientists and civil servants alike, subscribe to the view that a massive investment in science and technology would somehow solve most of our problems and change the socio-economic profile of this country. But despite this widespread belief in the efficacy of science, not many of us have a clear understanding of what science is all about, what the relationships between science and technology are, and how science is (or, can be) applied to the problems of real-life.

If someone were to ask, " what is science about ", most practising scientists are likely to answer that in our normal interactions with the external world we observe certain uniformities, regularities, or patterns. Certain classes of objects look similar in many details. Certain pairs of events routinely follow each other. Lightnings, for example, occur when there are storm clouds, but seldom in a cloudless sky. Bodies at rest, when unsupported, fall to the ground. There is a correlation between the angle at which a gun is held and the distance travelled by the projectile. These uniformities, regularities, and patterns, are a consequence of the fact that natural phenomena are governed by laws. It is the purpose of science to determine these laws and to systematise the relationship between them.

But if we try to pursue this inquiry a little further and ask for the relationship between observation and experiment, or between experiment and theory, or about the nature of scientific laws and their role in theory, it will be found that most practising scientists do not have an analysed view about these issues. Evidently, it is possible for someone to function as a competent scientist without at the same time having an articulated awareness of the nature of the activity one is competent in. Competence in most skilled activities is presumably of this type.

Again, consider the relationship between science and technology. It is customary to discuss the social relevance of science in terms of the technological applications that stem from it. But, historically, technological accomplishments have long preceded the growth of science as an organised activity. This is true of technological developments in agriculture, animal husbandry, mining and metallurgy, and a variety of other useful arts. Clearly, these early technological achievements must have been based on knowledge acquired at the commonsensical level and systematised in various prescientific ways. It is relevant to ask whether there are any substantive differences between such technological achievements based on commonsensical knowledge and those based on science as an organised activity as practised now. We should hope the differences are many and significant, for, otherwise, there would be little justification for supporting science from public funds.

Let us try to develop in the rest of this article a systematic account of the nature of science and scientific activity and see whether we can find satisfactory answers to the questions we have raised above. But first a word of caution. We must be extremely careful not to confuse science with physics or, even with the physical sciences. Physics has been responsible for some of the most spectacular developments in science during the last three centuries. Hence, physics has come to be looked upon as a paradigm of all sciences.

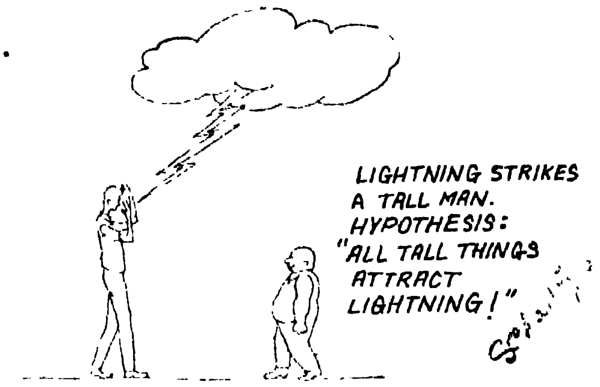
However, this is at best a partial truth. We cannot attempt to build a comprehensive theory of science by first assuming that all science conforms to (or should conform to) physics. There are very many aspects of the world that physics does not concern itself with. For instance, the behaviour of organisms. We must stand outside physics and try to characterise science in the most general way possible. Given such a really generalised account of what science is about and of the nature of scientific activity, we can then ask, " How does physics relate to this view of science? ", " What would a science of organismic behaviour look like? ", and so on.

Science and commonsense

LET US USE THE terms " naive " and " commonsensical " as interchangeable attributes to characterise activities engaged in, and objects and behaviour observed, in our normal, everyday living. Naive observations are about objects, agents, properties, relationships and behaviour that we encounter in our day-to-day living, and which we talk about using our ordinary (natural) language, for example, English, Hindi, Marathi, Tamil, and so on. It is a fact of life that, as we grow from childhood, our competence in naive observation and the use of ordinary language improves and enables us to acquire more or less dependable knowledge of the world around us. As we saw earlier, such knowledge systematised in various ways has given rise to technological developments of surprising sophistication.

How does commonsensical knowledge differ from scientific knowledge? Let us analyse a concrete example.

It is a naively observed fact that occurrences of lightning are related to the presence of storm clouds. It was known even to the ancients that lightnings strike tall objects (such as tall buildings and trees) much more frequently than


LIGHTNING STRIKES A TALL MAN. HYPOTHESIS: "ALL TALL THINGS ATTRACT LIGHTNING!"
CS

short ones. Objects struck by lightning are damaged in characteristic ways: they are crushed, badly burnt, or blown apart as if subjected to an explosive force. Lightnings are observed to have characteristic shapes. Sheet lightnings, fork lightnings, ball lightnings are some of the names characterising these shapes. Thunder either accompanies a lightning or follows it.

What is the nature of lightning? How does one account for its occurrence and all its associated characteristics as naively observed? We now know that there is static electric charge accumulations in cloud formations. Thunder clouds typically have most of their lower sides negatively charged, their upper sides being positively charged. As negative charges build up in the undersides of clouds, positive charges appear on the earth's surface beneath these clouds due to induction. Due to electrical forces of attraction these positive charges move up any conducting or partially conducting object like metal towers, buildings, or trees and give rise to an electrical discharge, provided the electric field intensity is sufficiently high. Thus, lightnings are of the nature of electric discharges between the clouds and the earth, or between two clouds. Their characteristic shapes are determined by the conditions of the atmosphere at discharge time. As lightning strikes an object, there is an impulsive current flow of very high magnitude to begin with, followed by larger duration current flows of smaller magnitude. The resulting magnetic and thermal effects account for the characteristic aspects of lightning damages. Thunder arises from the sudden pressure gradients that accompany lightning.

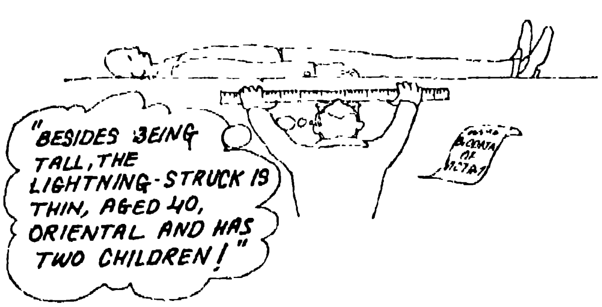
This is the nature of the scientific explanation at present generally accepted to account for lightning phenomena and their accompanying effects. A scientific theory set up to support such an explanation has to answer two questions: (1) What is the process by which charge accumulation takes place in storm clouds? (2) What is the nature of the electric discharge process that manifests itself as lightning? To understand how a scientific theory is built up, let us see how one would attempt to answer the second question.

A SCIENTIFIC THEORY set up to explain the electrical discharge phenomenon must concern itself with the system of laws that govern electrical discharges. How would one go about formulating such a theory? First of all one would have to determine what is it about electrical discharges that calls for an explanation. That is, one must determine at the phenomenological level what properties and relationships associated with electrical discharges call for explanations in terms of an articulated theory. Notice that naive observations do not provide these phenomenological details accurately. Such details can only be determined through systematic experimentation procedures.

The truth of this assertion can be seen by considering some specific examples. Naive observation leads us to believe that force is necessary to keep a body moving at constant velocity. The role of friction is not immediately obvious. In fact, Aristotle thought that impressed force was necessary to maintain a body in motion with uniform velocity. It was the controlled and systematic experimentation of Galileo that showed that the phenomenological relationships involved here are more complex. Apparent relationships deduced from naive observations more often than not tend to be wrong because of the role played by hidden factors in natural phenomena. Much folklore about human and animal behaviour, and belief in "miracles" of various kinds, presumably arise from the incomplete accounts of the behavioural relationships as naively apprehended. The story of Clever Hans is a good illustration in support of this thesis (see box on p. 18).

In the particular example under consideration, one might first try to perform an experiment by electrically charging, artificially, two bodies at close vicinity to see if a discharge occurs. One would note the relationship between the discharge and the distance between the bodies. At this stage it might have been noticed that the shapes of the bodies affect the discharge. This would then call for more experiments to explore this relationship. Then it might turn out that the medium filling the discharge gap is also a relevant parameter determining the discharge. So, further experiments may be called for. After accumulating relationships between several parameters, we may be able to construct a theory in terms of intensities of electric fields, the ionisation potential of the medium, and other factors. Finally, we might find that all these empirically determined relationships are derivable from the basic laws of electromagnetic theory together with properties of the medium, shapes of the bodies, their distances apart and similar aspects of the experimental situation.

From a theory so constructed we should be able to enunciate laws of the form: if bodies of such and such a shape are electrically charged in a medium with such and such properties, discharges of such and such specified nature will occur. These laws can be verified by performing experiments of the type discussed earlier but now satisfying the initial and boundary conditions stipulated in the law.


"BESIDES BEING TALL, THE LIGHTNING-STRUCK IS THIN, AGED 40, ORIENTAL AND HAS TWO CHILDREN!"

FROM OUR ANALYSIS so far it is evident that experiments and theories are very intimately connected. To begin with, experiments enable us to delimit phenomenological relationships to account for which theories are invoked (or constructed, if not available initially). The statements or consequences derived from theory are verified by experiments. The predictions of a theory, thus, are predictions of occurrences of events in experimental situations. So, if one wants to know what are scientific theories theories of, the answer is 'they are theories of experiments', or more precisely, 'they relate to properties and relationships determinable in experimental situations'.

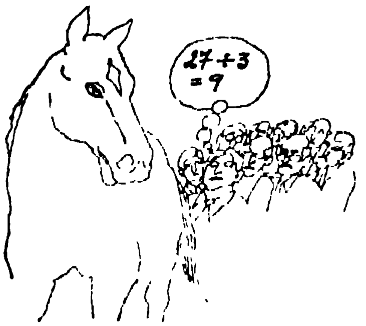
We are by now far removed from the naive observation of lightning and storm clouds that we began with. The popular view that science is about the naively observed uniformities or regularities of nature is clearly somewhat simplistic. Uniformities and regularities relate

The Story of Clever Hans

CLEVER Hans was a horse that had been trained by its owner, Von Osten, (in Germany around the turn of this century) to give numerical answers to questions by tapping on the ground with one of its forelegs the appropriate number of times. The horse could answer correctly problems involving simple arithmetical computations. It could convert common fractions into decimals and back again. It could tell the time. It could do all these whether the problems were posed by its owner or by anyone else.

Clever Hans's performance was incredible enough to convince a specially appointed commission of eminent zoologists and psychologists that the horse really understood the problems and solved them. It was finally demonstrated by Pfungst, a psychologist, that Clever Hans could only answer correctly when the questioner was aware of the statement of the problem and knew the correct answer himself. In order to know whether the horse was giving the correct answer, the questioner had first to solve the problem himself and then to count subvocally as the horse tapped out its answer. After the last of the expected taps the questioner would relax ever so slightly, thus inadvertently and unconsciously making a tiny movement. This almost imperceptible visual cue was being made use of by Clever Hans to stop tapping (after the correct number of taps).

This explanation sounds so far-fetched on first encounter that it is evident nobody would have taken it seriously if Pfungst had not demonstrated it convincingly through controlled experiments. Pfungst was very easily able to mislead the horse by providing deliberately this visual cue inappropriately. He was thus able to elicit out of the horse any answer he chose for a given problem.

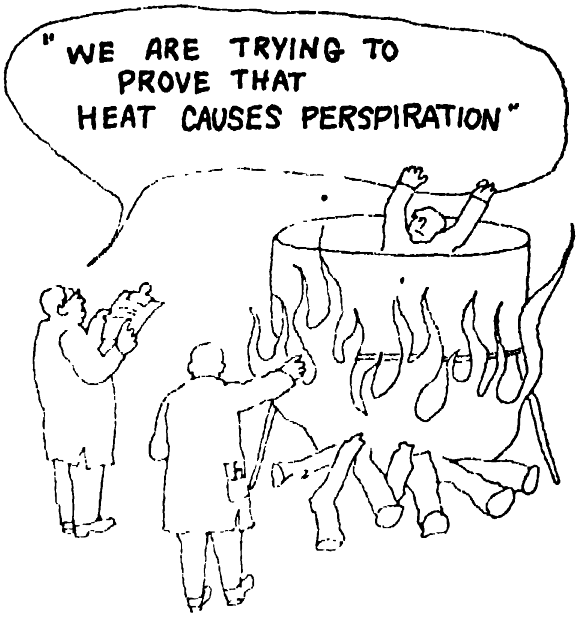


only to controlled situations; that is, experimental situations. Regularities exist in the open-ended world only to the extent to which the contextual parameters determining phenomena remain more or less invariant. Science can hardly ever predict what happens in the open-ended world. Meteorological predictions are usually so unsatisfactory precisely because the meteorologist, unlike the atomic physicist, can exert very little control over the situational aspects he is dealing with.

It might seem that astronomical observations contradict these assertions. For, are we not able to predict astronomical events without controlling them? But, on closer analysis, it will become evident that this is a fallacy. As Jevons points out, ". . . . astronomers . . . select precise times and places for important observations of stellar parallax, or the transit of planets. They make the Earth's orbit the basis of a well-arranged *natural experiment*, as it were, and take well-considered advantage of motions which they cannot control". That astronomical "observations" really constitute elaborate experiments will be obvious to any one familiar with the sophisticated photographic, spectrographic and electronic instruments used by astronomers for data collection and analysis.

The popular saying 'every rule has an exception' literally applies to the rules inferred from the naively observed behaviour of the open-ended world. Part of the objective of science is precisely to account for these exceptions. Theories that deal with regularities in the behaviour of prepared systems under controlled conditions provide the basis for accounting for these exceptions. We say, " this exception was encountered in this uncontrolled environment because such and such a constraint necessary for the regularity was missing here ". A theory allows us to deduce the consequences of relaxing specific constraints in well-defined ways.

IN WHAT SENSE, then, does science relate to naively observed phenomena? How are we able to account for such phenomena in terms of a theory which only relates to experimentally verifiable situations? The answer is that a theory is applicable to a naively observed situation to the extent to which it approximates the relevant experimental situation. If the approximation is good, predictions based on theory are verified. Otherwise, not. We account for the occurrence of lightning in a clouded sky by saying that the situation out there is similar to our experimental set up with two charged bodies giving rise to an electrical discharge. If someone doubts this and demands a more convincing proof, we could try and probe the natural environment for indications that the relevant properties and relationships do indeed hold out there. Like Benjamin Franklin, for instance, we could send up a kite into the clouds and establish that in fact the clouds are electrically charged and the lightning is electrical in origin.


"WE ARE TRYING TO PROVE THAT HEAT CAUSES PERSPIRATION"

It is this fact, that situations of the open-ended commonsensical world approximate more or less the situations of an experimentally controlled world, that gives rise to naively observed regularities of the external world. If we wish to, we could look upon this as a happy accident. Science as an organised activity might not have got started but for this feature of the world.

So far we have informally developed the thesis that science is about experiments, and that predictions and verifications of a theory both relate to experiments. Verification and prediction are two sides of the same coin, so to speak. To deal with the relation between 'theory' and 'experiment' in greater depth, we have to discuss these concepts in more technical detail.

Relationship between experiment and theory

A SCIENTIFIC THEORY relates to a class of experiments and accounts for (or explains) the observed behaviour (or, equivalently, predicts the behaviour, as we have seen). The realised behaviour, thus, is a function of two factors: (1) the experimental set-up (ie, the way the environment has been prepared), and (2) the interaction pattern. If the one or the other is changed, in general, one should expect the behaviour to change. Predictions based on theory, then, can only be made subject to the specification of both these factors. Let us consider these factors in more detail.

An experiment is a controlled interaction with a prepared environment. Specifying an experiment requires the specification of four components:

(1) Specification of the initial and boundary conditions of a delimited environment (ie, the preparation of the experimental set up).

(2) Specification of the interaction procedure (ie, of the manipulatory part of the experiment).

(3) Specification of the observations to be made (ie, the data acquisition part of the experiment).

(4) Specifications of the computations to be performed on the observations (ie, the data analysis part of the experiment).

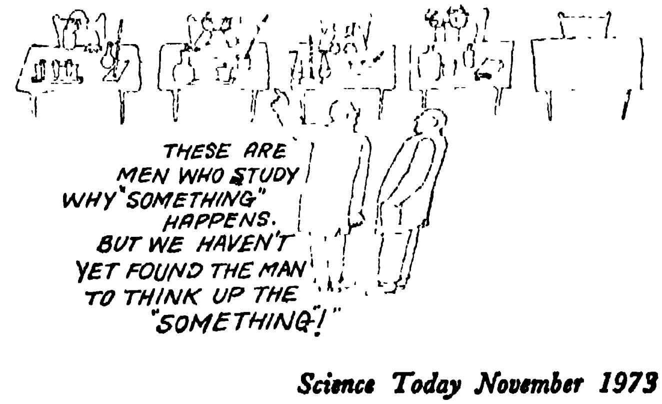
The usual procedure is to give these specifications as sets of statements: (1) prepare an environment of such and such a nature through these and these means; (2) interact with it using the specified input-output channels according to the following procedure; (3) observe the following aspects of behaviour by gathering these kinds of data from the input-out channels; (4) analyse and reduce the data using these and these computational procedures and generate results of the following kind.

Notice that carrying out an experiment in this manner presupposes the availability of, (1) a *language* in which such specifications can be given, and (2) an *agent* (experimenter or observer) who can interpret the specifications and carry out the experiment as specified. One can readily convince oneself that in order to base the verification process on objective criteria it is essential to specify an experiment in a computationally exact manner; that is, at every stage of the experiment one should be able to determine *mechanically* whether the relevant specifications have been met or not. When an experiment is specified in this exact manner, we can construct an automaton to interpret the statements and carry out the intended tasks. The possibility of automating laboratory experiments is precisely predicated on this logical requirement of mechanical verifiability.

A word of caution is perhaps necessary at this stage of our discussion. We have been talking about experiments in two different contexts without taking care to distinguish between them. Our discussion of experiments in the present context refers to performing experiments to verify theoretical predictions or the consequences of explicitly stated hypotheses. We emphasised that these experiments should be specified in such a way that a computer or automaton (with appropriate sensors and effectors) could carry out the experiments and verify the predictions. Earlier, while talking about constructing a theory to account for lightning phenomena, we dealt with *exploratory experiments. Thinking up exploratory experiments to construct theories is a creative activity.*

The creative aspects of this process are as yet not well-understood. The so-called inductive view of science holds that it should be possible to enunciate logically rigorous procedures for performing experiments and extracting theories out of them. This view is currently not accepted by most philosophers of science. According to the hypothetico-deductive view of science, on the contrary, there is an irreducible nonlogical aspect to scientific theory construction (and, hence, to thinking up exploratory experiments). Thinking up hypotheses is essentially a creative activity. But once thought up, their implications have to be worked out in detail and their

If someone wants to know what are scientific theories theories of, the answer is "they are theories of experiments"!


THESE ARE MEN WHO STUDY WHY "SOMETHING" HAPPENS. BUT WE HAVEN'T YET FOUND THE MAN TO THINK UP THE "SOMETHING"!"

validity tested through critical, controlled experiments. This is a strictly deductive activity. These experiments being of a strictly verificatory nature must meet all the criteria we discussed earlier.

An experiment, as we have just discussed, is a particular controlled interaction with a prepared environment. Performance of every such experiment leads to a why-question of the following kind: " Why is it that if I do so and so, I observe such and such an outcome (or, such and such an outcome results) ? ". A scientific theory that relates to this experiment answers this why-question as follows: " Doing so and so means setting up these specifications; that is, assigning these values to these variables and getting them to satisfy these relationships. Thus, these and these antecedent conditions are satisfied. The consequences of these assignments and carrying out the procedures of the experiment can be deduced using these and these statements of the theory. This deduction assigns these and these values to this set of variables resulting in these relationships. These results, interpreted again, correspond to the observed results of the experiment."

WHY-QUESTIONS CAN be answered meaningfully only within an assumed theory. A theory is satisfactory to the extent to which all its derivable consequences are verified through experiments. It is now customary to exhibit a scientific theory as a formal system with an appropriate interpretation. To specify a formal system one has to specify its vocabulary, formation rules (ie, rules for the construction of the well-formed formulae of the system), axioms and rules of inference. The vocabulary is usually divided into two parts: the logical vocabulary and the nonlogical or descriptive vocabulary. The descriptive vocabulary consists of all the theoretical terms of that particular theory. Similarly, the set of axioms can be divided into logical axioms and nonlogical axioms which contain the empirical content of that theory.

Before trying to axiomatise a theory we must be clear what other theories are to be assumed as being available in developing the axiomatisation. This assumed context within which we try to axiomatise a theory would delimit the primitive notions of that theory. (The primitive notions of a theory are the notions that are used as the building blocks of that theory. They are postulated without further analysis.) In the physical sciences, like physics and chemistry, it is usual to assume the availability of much of predicate logic and set theory, as also appropriate portions of mathematics (for example, calculus, differential equations, probability theory, and so on). It would be extremely cumbersome to start at such a primitive level as to require the simultaneous formal development of all this background along with the specific scientific theory itself.

IT'S FUNNY! I PUT THE SAME AMOUNT OF SULPHUR TWICE AND THE AMOUNT HAS DOUBLED!
OH! THAT'S CALLED ADDITION– YOU KNOW— 2+2=4!

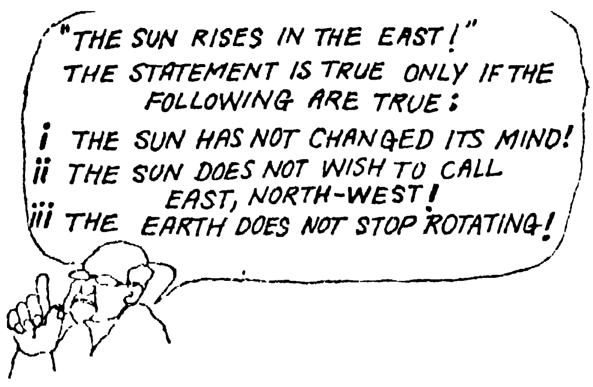
The nonlogical axioms which embody the empirical content of a theory are the ones which are usually presented informally in text-books as constituting the basis of a theory, for instance, statistical mechanics, quantum mechanics, electromagnetic theory, etc. There are several kinds of axioms belonging to the nonlogical part:

(1) Law-like generalisations which usually specify relationships between properties of theoretical terms (eg, Newton's Laws, Maxwell's Equations, etc).

(2) Statements concerning the attributes of theoretical terms (eg, electron has a mass, charge, . . . etc).

(3) Statements assignings values to specific attributes of theoretical terms (eg, electron has a charge equal to $4 \cdot 77 \times 10^{-10}$ electrostatic units, etc).

We must note that, although text-book treatments often formulate a law as if it were valid unconditionally and universally, strictly speaking, a law is not completely specified unless the boundary conditions for its validity are explicitly stated. This, of course, may not be always possible since the limits of a law may not be sharply defined: a law may be more or less accurate. Also, the limits of a law may not be known. For instance, till the time of Einstein, Newton's laws were believed to be unconditionally valid. Still, it is important to note that


"THE SUN RISES IN THE EAST!"
THE STATEMENT IS TRUE ONLY IF THE FOLLOWING ARE TRUE:
i THE SUN HAS NOT CHANGED ITS MIND!
ii THE SUN DOES NOT WISH TO CALL EAST, NORTH-WEST!
iii THE EARTH DOES NOT STOP ROTATING!

a law, theoretically, has to have the form of a conditional statement: if such and such, then such and such.

A theory, axiomatised along the lines we have been discussing so far, is still only a formal deductive system without an assigned interpretation. It is no different from a theory in pure mathematics. It is the assignment of an interpretation to an axiomatised theory that connects its nonlogical axioms, as well as the derivable consequents of these axioms, to experiments. The formalisation of this interpretation assignment process is still in a very unsatisfactory state. It is customary, in the philosophy of science, to discuss this process making use of notions like, 'correspondence rules', 'dictionary', 'meaning postulates', and so on. But these discussions, which are all very informal anyhow, do not really come to grips with the central issues involved in the interpretation assignment process. (It will take us too far outside the scope of this article to discuss these issues in greater detail here.)

The role of measuring instruments

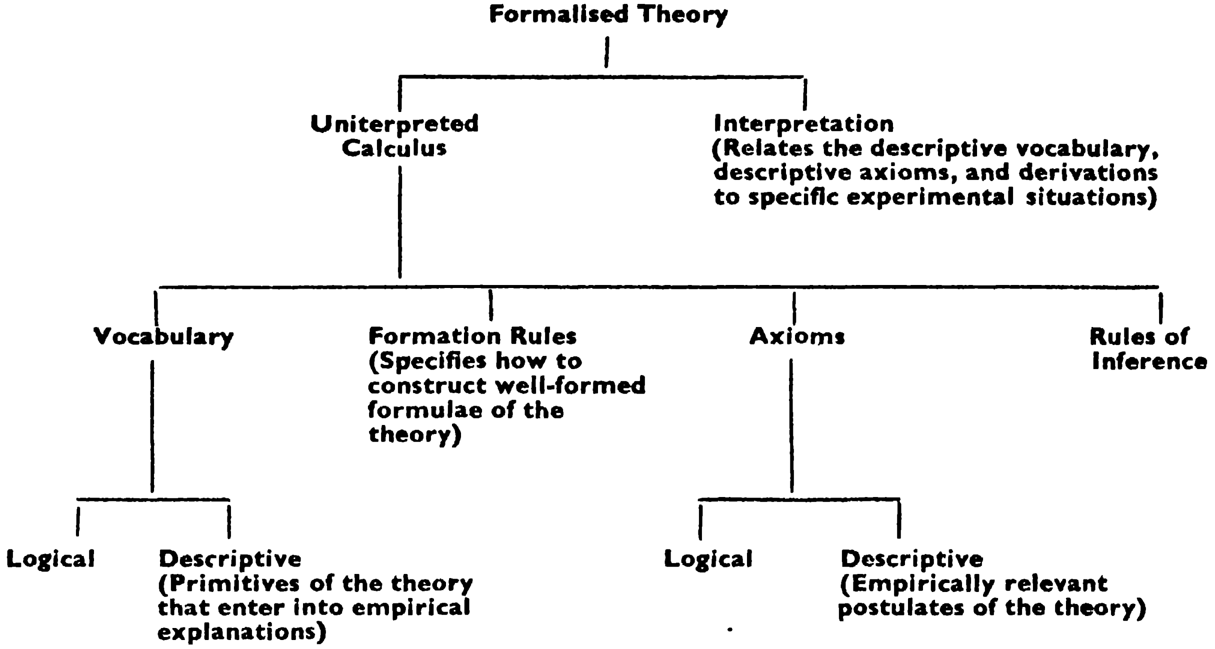
EARLIER WE SAW that in specifying an experiment the first requirement is the specification of the experimental set up. The initial and boundary conditions of the delimited environment (involved in the experiment) have to be specified. A direct specification could take the form: "Set up an electric field of intensity such and such", "establish a charge configuration of such and such a pattern", etc. While preparing an environment to meet these specifications, the experimenter must have some means of ensuring that the specifications have in fact been met in the experimental set up. The standard way of accomplishing this is through the use of appropriate instruments that constantly monitor and control the environment. Hence, giving meaningful specifications presupposes the availability of appropriate instruments for probing, monitoring, and controlling the environment. From this it also follows that the applicability of a theory (ie, its empirical relevance or significance) is circumscribed by the level of available technology. For, the predictions of a theory might call for experimental specifications which cannot be achieved through the use of available instruments.

In using instruments to perform experiments, the following question naturally arises: "What determines whether a given instrument is an appropriate one or not for establishing some specified condition?" The answer is, "It is a theory that determines this". A scientific instrument has certain aspects of a related theory permanently wired into it. One knows that a voltmeter in fact measures voltages because of the principle of operation of that voltmeter. And these principles are based on the relevant portions of electromagnetic theory, say, which enables a pointer to indicate a number on a scale corresponding to the potential difference across the terminals to which the voltmeter is connected. Thus, every instrument presupposes a theory which sanctions the functional relationships embodied in its hardware as being the relevant ones for the task on hand. Hence, the level of available instrument technology is delimited by the level of available theory. This implies that controlled experiments (ie, scientifically significant interactions with one's environment) are possible only on the basis of some assumed theory.

WHAT? THE RAINBOW HAS 7 COLOURS?
BUT THIS INSTRUMENT CAN COUNT ONLY UP TO 5!

But earlier we saw that experiments are indispensable to isolate and discover phenomenological relationships before a theory can be constructed to account for these. We are hence led to conclude that performing experiments and constructing theories are two aspects of an integral activity. It is not really very

Formalisation of Theories


Formalised Theory
Uniterpreted Calculus
Interpretation (Relates the descriptive vocabulary, descriptive axioms, and derivations to specific experimental situations)
Vocabulary
Formation Rules (Specifies how to construct well-formed formulae of the theory)
Axioms
Rules of Inference
Logical
Descriptive (Primitives of the theory that enter into empirical explanations)
Logical
Descriptive (Empirically relevant postulates of the theory)

Scientific theories take for granted the logical infrastructure provided by predicate logic and much of set theory. In addition, specific portions of mathematics are assumed, eg, differential and integral calculus, theory of real and complex variables, theory of differential and integral equations, probability theory, and so on. The descriptive vocabulary and axioms of physical theories are seldom explicitly and formally exhibited.

In other words, axiomatised versions of very few aspects of physics and chemistry really exist. Attempts have been made by various people to formulate explicitly the descriptive axioms of classical mechanics, statistical mechanics, and quantum mechanics, among others. Practising scientists, however, seldom show any real interest in such efforts. This, in a way, is unfortunate, for formalisation assists in logical clarity. Much of the mysticism concerning the role of mathematics in science is a direct outcome of sloppy logical thinking.

meaningful to ask, " which comes first, experiment or theory ?" This integral relationship between theory and experiment also provides a basis for relating naively acquired knowledge and experimentally acquired knowledge. Naive knowledge acquisition is possible at all only because of the attribute and relationship-computing capabilities built into the sensor and effector mechanisms of human beings. In other words, certain rudimentary measuring instruments are available to human beings as part of their genetic endowment. Commonsensical interaction with the environment and commensensical language-usage enable human beings to experiment and theorise at the naive level. But naive knowledge so acquired is limited in scope and often undependable because of (1) the limitations of the sensor and effector mechanisms, (2) the absence of controls in the interaction process, and (3) the unsystematised theoretical bases that are used to interpret and draw inferences from observations.

IN DISTINGUISHING between naive and scientific knowledge it is important to be aware of the distinction between objective and subjective measurements. A measuring instrument, as we saw above, is designed (or prewired, or programmed) to measure some preselected aspect of the external environment. Even if the external environment is under strict experimental control, the output of the measuring instrument would, in general, depend on its internal environment. When its internal environment is also under strict experimental control, the measurements are strictly repeatable and the results are said to be the outcome of an objective measurement. When a living organism (say, a human being) functions as a measuring instrument, its internal environment is not under strict experimental control and the measured results will, in general, vary depending on the state of its internal environment. The results are then said to be the outcome of a subjective measurement.

Taking science out into the world is of the nature of performing an experiment. It consists in constructing an artificial world out of a delimited part of the natural world so that this artificial world can be made to approximate an experimental situation as closely as possible . . .

One class of psychophysical experiments is concerned with correlating objective measurements with subjective measurements; where the independent variable is the internal environment of the (subjective) measuring instrument (ie, a human being). Notice that, when the external environment is suitably prepared, the results of the subjective measurements could be used to make statements about the internal environment of the measuring instrument. This is true whether the measuring instrument is a hardware or a human being. This assumes, of course, that one has a plausible theory to justify drawing inferences of that kind. This requirement is automatically fulfilled in the case of the usual scientific instruments since their principles of construction are known. This knowledge, in conjunction with our knowledge of the environment they are supposed to be measuring, allows us to infer why they are misbehaving (ie, why their measurements are subjective). This same principle can be extended to the case of living organisms in certain special circumstances. Several psychological tests (eg, personality tests) and medical diagnostic tests make use of this principle.

Types of scientific research

IN TERMS OF OUR account of experiments, theories and their interrelationships, we can discuss the various kinds of scientific activity that together make up professional research. We can distinguish the following categories:

(1) Invent new scientific instruments so that new kinds of experimental set-ups could be prepared.

(2) Perform new experiments to verify or disprove predictions of current theories and generate new why-questions for theory to answer.

(3) Enlarge the scope of a given theory by deriving new consequents (theorems) from its axioms. Some of these consequents could account for the why-questions generated in (2) above. Others would be of the nature of predictive assertions yet to be confirmed by new experiments.

(4) Augment or refine a given theory by adding to its primitives and axioms, or modifying existing ones. This may be necessary to answer some of the why-questions generated in (2) above. This may be also necessary to make more exact predictions.

(5) Given a set of independently developed theories, construct a single theory having the same explanatory and predictive power as the other theories put together.

(6) Given a set of phenomenological relationships arrived at through exploratory experimentation, construct a theory to account for these.

Of these various categories, (5) and (6) are considered to be the most significant scientific activities from the point of view of the advancement of science. The contributions of Newton, for example, belong to these categories. Category (4) could also have, at times, fundamental and far-reaching consequences. Most so-called scientific revolutions have resulted in radical changes in the theoretical primitives and axiom schemes in current use or, at times, replacement of one theory by another almost completely. The contributions of Einstein and the revolution introduced by quantum concepts are notable examples of such changes.

It follows as a corollary that of all experimental activities, those that give rise to theoretical activities belonging to categories (4), (5) and (6), should be considered as scientifically the most significant. An experimenter, to be aware of the significance of his work in this sense, must himself be theoretically highly competent. History of science seems to support this conclusion. Most great scientists have been equally proficient in theory and in experimental techniques.

(TO BE CONCLUDED)

Professor Narasimhan heads the Computer Group at the Tata Institute of Fundamental Research at Bombay. An MS from CalTech, Pasadena, he took his MA and PhD from Indiana University, both in the USA. He has been with the TIFR since 1954 and is now working on computer models for visual perception and language behaviour.

This article is based on part of the work done by him during his Jawaharlal Nehru Fellowship (1971-73).

round-up of research

PHYSIOLOGY

Sleepless? Maybe Your Lungs Fall Asleep!

IF you are suffering from sleeplessness, the chances are that your lungs go to sleep instead — you may not respire for a total period of 20 to 30 minutes during your sleep. In fact, your breathing mechanisms might be going hay-wire.

The new clinical syndrome — insomnia with sleep apnoea or the cessation of breathing during sleep — has been discovered by three doctors of the Stanford University School of Medicine, California, USA. The discovery was made possible by the routine respiratory studies now being carried out in their clinic on all patients suffering from insomnia.

Sleep apnoeas have been recognised before in the cardio-pulmonary syndrome of obesity (' Pickwickian ') and in cases of hypersomnia or unnaturally deep sleep. The reports by Drs. C. Guilleminault, F. L. Eldrige and W. C. Dement in *Science* (*181*, 856, 31 August 1973) is the first indication of the association of sleep apnoeas with insomnia.

The report is based on the studies conducted on three males above the age of 55 who had each suffered from insomnia for more than twenty years. All three had a history of several arousals during the night, and difficulty in maintaining their sleep, particularly in the early morning. Sleeping pills and barbiturates did not alleviate their condition, and they snored in sleep. In one patient, the wife had noted cessation of breathing while he was asleep.

When the patients were awake, measurements were made of lung volume, air flow resistance and the amount and presence of oxygen and carbon dioxide in their blood. The results of all these tests were well within normal limits.

When they were in bed at night, an ear oxymeter continuously measured arterial oxygen saturation. In addition, pressure changes in the lungs were monitored and recordings of brain activity were carried out with an electroencephalogram, differential electro-oculogram and intercostal electromyogram. The pressure changes in the lungs made it possible to determine the duration of each apnoea and its correlation with the arousal as indicated by the electroencephalogram.

The respiratory studies indicated that the patients had frequent and repeated episodes of apnoea during their sleep which often lasted for 20 to 30 minutes. Serious sleep disturbances were found to be directly associated with the apnoeas. The cyclic recurrence of the apnoeas was ended only by complete conscious arousal of the patient for 5 to 15 minutes. However, not all the apnoeas were recurrent and occasionally short apnoeic periods would interrupt normal breathing without waking the subject. The mean duration of each apnoea was about 30 seconds, though some lasted as long as 150 seconds.

One of the patients had a significant increase in blood pressure during apnoeas. According to the Stanford scientists, it is unlikely that the cardiovascular changes will lead to a permanent damage of the lungs or blood vessels of an otherwise healthy person. It is possible, however, that it might worsen other pathological conditions in a patient. Hence, they suggest that the possible interaction of sleep apnoea and insomnia with heart disease should be considered. It is also possible that the night death of some patients with heart troubles could be related to sleep apnoea.

One important conclusion of the study is that an unknown proportion of patients complaining of chronic insomnia may have profound disorders of their respiratory control mechanisms.

EXPLOSIONS

What Happens When Molten Metal is Dropped in Water

VAPOUR explosions, also known as fuel-coolant interactions, can occur when a hot liquid comes in contact with a cold vaporisable liquid, at a temperature much above the cooler liquid's boiling point. No chemical energy is released, the energy source for the explosion coming solely from the excess heat of the hot liquid.

Both the nuclear power and the liquified natural gas (LNG) industry are interested in the study of these explosions, since liquid sodium (a coolant used in some reactors) mixed with molten uranium dioxide fuel is explosive, and so too when liquid natural gas (coolant) mixes with water (fuel). Fuel-coolant interactions can also occur on dropping molten metals in cold water, and recently scientists are considering what might happen if volcanic lava were to be intimately mixed with sea water.

The previous explanation of these interactions was based on a model of the reaction of LNG with water. The idea was that the water heats the LNG to a superheated state, when large amounts of liquid expand violently as vaporisation occurs. Drs. D. J. Buchanan and T. A. Dullforce of the Culham Laboratory, Berkshire, England point out in an article in *Nature* (*245*, 32, 7 September 1973) that this simple idea cannot completely account for all fuel-coolant interactions. They have proposed a different mechanism for vapour explosions and supported it by high-speed cine films of experiments with molten tin and water.

The basic problem is that the explosions occur so fast that a great deal of heat energy must be transferred from the fuel to the coolant within tens of milliseconds. This requires a large surface area of intimate contact between the fuel and the coolant, which is possible for water and LNG, which have similar densities. But, if molten metal is dropped in water, the two very different liquids do not spread to form a large area of contact and, hence, for the explosions to occur, something different must be happening at the liquid metal/water interface.

The Culham scientists suggest that any bubble of water vapour formed initially as the two liquids come in contact will collapse rapidly due to the cooling effect of the bulk of the cold fluid around it. The collapse will produce a jet of the coolant directed towards the surface of the hot liquid. If this jet can penetrate the hot liquid, then a relatively efficient mixing of the two will occur, resulting in heating the small amount of water inside the liquid metal explosively. The explosion will spread the fuel among the remaining coolant like ' the spray of water produced by a depth charge '. Since the cycle of formation and collapse of the vapour bubble will occur all over the boundary between the metal and water, explosive vaporisation of large amounts of water will occur.

The films show, as expected, that the interaction proceeds in a series of cycles as each generation of bubbles produces its own depth charge effect. In addition, examination of the debris left by the explosions indicates that the jets of coolant have, in fact, penetrated into the liquid metal before it exploded.

MOLECULAR BIOLOGY

How Does DNA Make Copies of Itself?

IT is now widely known that the hereditary information is contained in the DNA molecules of the chromosomes. When a cell divides, the chromosomes also divide, and an exact copy of the DNA molecules in the original chromosome is transferred to the daughter. This process is known as DNA replication.

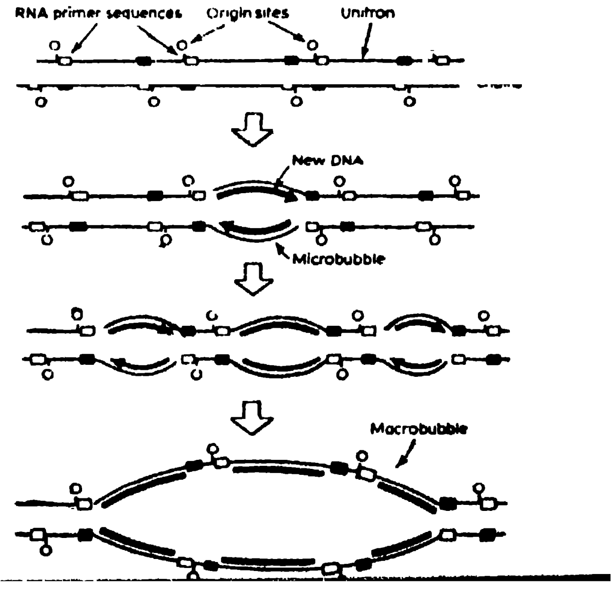
A number of models have been proposed in the past to explain DNA replication. However, all of them fail to account for at least some salient features, notably, the involvement of RNA synthesis as a primer or initiator, and the complicated problem of the unwinding of the two long DNA strands coiled in the form of a helix.

A new model which is claimed to be consistent with all the known facts has been proposed by Dr. P. Ioannou of the Department of Biochemistry, University College of London, England in an article in *Nature New Biology* (*244*, 257, 29 August 1973).

The following essential points characterise Ioannou's model. The DNA replication is

A possible way in which DNA might replicate itself. Replication takes places at several sites on a single chromosome simultaneously, resulting in the formation of ' microbubbles '. Adjacent microbubbles coalesce to form a ' macrobubble '

Courtesy: NEW SCIENTIST



bidirectional, and is based on units of replication called ' unitrons ' of which there are many separated by variable distances in different DNA species. There exist pairs of initiation sites at the two ends of the unitron, and at these sites, on each strand, a short DNA sequence codes for an RNA primer of about 50 ribonucleotides. Before the RNA synthesis occurs, the parental DNA strand gets itself severed at the initiation sites at opposite ends of the unitron. Once the complementary RNA primer has been synthesised, the DNA replication begins. The new DNA will be complementary to the remaining single strands of DNA in the unitron. As the two new DNA chains grow towards and past each other, the parental strands can unwind, since they are already snipped at the initiation sites. The resultant four-stranded structure, containing two new complementary DNA chains, Dr. Ioannou calls a ' microbubble '.

The RNA primer sequences are then removed, and, according to the model, microbubble formation can spread to adjacent unitrons, allowing the replicated DNA units to join together to form a macrobubble; the gaps between the two new DNA fragments are filled by normal repair mechanisms. The macrobubble spreads (either in one direction or both) until about 100 unitrons constituting a replicon are involved.

The model is consistent with many observed and known features of DNA replication. For example, there is now considerable evidence in favour of bidirectional replication. Unidirectional replication demands that the whole DNA molecule in *Escherichia* chromosomes unwinds at about 10,000 revolutions per minute, which is not feasible. Further, multiple sites for DNA initiation and an RNA primer are known to be universally involved in DNA synthesis in viruses, bacteria and higher organisms. Microbubbles have also been observed by electron microscopy and autoradiography.

COSMOLOGY

More About the Quizzical Quasars

QUASI-STELLAR radio sources (quasars) have been a puzzle to cosmologists ever since their discovery nearly 15 years ago. One of the most controversial issues has been the nature of the large redshifts observed in their emission spectra. The recent announcement of the detection of the 21 cm hydrogen line in absorption at a high redshift in the direction of the quasar 3C 286 by two scientists of the US National Radio Astronomy Observatory in the *Astrophysical Journal Letters* (*184*, 7, 15 August 1973) may be an initial step in the solution of this problem.

One of the more intriguing aspects of many quasars has been the presence of numerous fine absorption lines in their optical spectra with redshifts different from those in emission. Some enigmatic objects, in fact, show a multiplicity of absorption line redshifts (see SCIENCE TODAY, p. 24, October 1969), each one less than the unique value or the redshift of the emission lines. To explain this bewildering array of spectral lines, some models of quasars had suggested the absorbing material as clouds ejected from it, while the absorption lines may also result if unrelated galaxies happen to lie along the line of sight.

Studying several quasars with the 100 cm telescope of their observatory having a receiver tunable in the frequency range 750 to 1,000 MHz, Drs R. L. Brown and M. S. Roberts discovered a sharp absorption line in the spectrum of 3C 286 at a frequency of 839·407 MHz. They identified it as due to the 21 cm hydrogen line with a redshift of 0·692.

The American scientists confidently exclude the suggestion that the observed line is due to some molecular recombination or due to an exotic molecular cloud within our Galaxy, since no such features occur in the sky near 3C 286. They also rule out absorption due to clouds ejected from the quasar, since the line itself has only a velocity spread of 8·2 km per second, whereas, if the mass of the absorbing hydrogen has been shot out of the quasar, it must be travelling away from it at 50,000 km per second to account for the observed emission redshift of the quasar, namely, 0·849.

This leaves an intervening galaxy on the line of sight between Earth and 3C 286 as the only really plausible origin for the observed absorption feature. The sharpness of the line, further, rules out the possibility that the redshift is caused by something other than the general expansion of the universe. One important conclusion from the experiments of Drs Brown and Roberts is that at least 81·5 per cent (ie, 0·692/0·849) of the emission line redshift of 3C 286 is truly cosmological.

K. A. Neelakantan

. . . and new processes

CHEMICAL ENGINEERING

New Catalyst for Propylene Oxidation

SILVER-BASED oxidation catalysts, used invariably in the production of ethylene oxide, are not suitable for converting propylene to propylene oxide in commercial yields. Now, Prof Bryce-Smith and co-workers at the University of Reading, UK, have reportedly developed an unusual type of silver catalyst which is extremely suitable for the oxidation of ethylene and propylene (*Chemical Engineering News*, 1972, *50*, (47), 22.) Ethylene oxidation occurs with a selectivity of 80 to 90 per cent at a conversion level of 50 to 80 per cent, without the need for promoters. An extension of the work has led to the discovery of a new class of highly active, transition metal catalysts

The discovery itself stems from the studies of metal ketenides, a hitherto unknown class of compounds. They may be formed in a variety of ways. Silver ketenide, for example, precipitates out in quantitative yields on mixing silver acetate in pyridine or triethylamine, with acetic anhydride. The anhydride interacts with the tertiary amine to form ketene, which, in turn, converts the silver acetate to silver ketenide. By heating or chemical treatment, it is possible to remove the ketene moieties from silver ketenide. Both silver ketenide and the silver that remains after its decomposition promote direct air oxidation of ethylene. It is claimed that the new form of silver " handsomely outperforms " conventional silver catalysts. Studies with propylene have shown that 20 to 30 per cent propylene oxide yields can be obtained. Although these would have to be increased to 50 per cent and above to make them commercially attractive, conventional catalysts are not at all effective in the oxidation of propylene. The results are, therefore, extremely important, and further development of the catalyst system may lead to a new process for the manufacture of propylene oxide.

In India, ethylene oxide is manufactured by the National Organic Chemical Industries Ltd, Bombay, who have a capacity of 12,000 tons a year. The use of the new catalyst system in the existing plant may increase the capacity and reduce the cost. Propylene oxide, however, is not produced in the country, and therefore the possibility of using the new process may be considered at this planning stage itself.

S. B. Chandalia

TEXTILES

Chlorite Bleaching Made Safer

THOUGH sodium hypochlorite, hydrogen peroxide, etc are the traditional textile bleaching agents, they cannot be used for bleaching synthetic fibres such as polyester and acrylic. They do not bleach at all. And that is how sodium chlorite came to be used. It is safer in that it does not attack most of the chemical fibres. But the problem is sodium chlorite bleaches effectively only under acidic conditions, and under these conditions it gives out corrosive and nauseating fumes. This leads partly to the wastage of the active ingredient in the bleaching agent and partly to a bad odour and health hazard.

The Midwest section of the American Association of Textile Chemists and Colorists have now found that the use of hydrogen peroxide contributes to the reduction of the chlorine dioxide gas during bleaching. In studies in the laboratory as well as in production units (*Textile Chemist and Colorist*, USA, 1971, p. 20), they found that a 5 per cent concentration of hydrogen peroxide (50 per cent) in the chlorite bleach baths was critical. Too much stabilisation and poor bleaching occurred when a 6 per cent solution was used. A 4 per cent solution was insufficient for stabilising.

What is important, however, is the order of addition of different chemicals to the bleach bath. Thus Orlon yarn can be bleached in a solution containing oxalic acid, hydrogen peroxide, sodium nitrate and sodium chlorite, the bleaching solution being heated to 210°F (155°C) at the rate of 3°F/minute and continuing the heating for 45 minutes.

V. A. Shenai

blurs & bright spots

Break the law . . .

WHEN nobody is looking. Or, better still, wait for someone else to do it first. Take, for instance, crossing a street when the " Don't Cross " sign is on. How many people wait till the " Cross Now " sign comes on?

Lionel Dannick, a sociologist with the Cazenovia College at New York, went ahead to find out and what he found is interesting. In his paper published in *The Sociological Quarterly*, Dannick says he watched 1,280 men and 775 women (individually) at street crossings. Ninety per cent of the men and seventy per cent of the women crossed the street against the " Don't Cross " sign when no one else was there.

What would they have done if someone *was* around? Dannick introduced an experimental condition: he made a model appear at the crossing just before each subject, and the model would either wait for the signal to change or cross over against it.

What happened? More law breakers, naturally! Where the model ignored the sign, 94 per cent of the men and 89 per cent of the women (against the earlier 90 per cent and 70 per cent nobody-around-figures) followed his example. Where the model waited like a dutiful citizen, 66 per cent men and 48 per cent women still crossed the street.

Dannick points out: the follow-the-leader action was more pronounced in women than in men. Does it mean women are more open to external stimuli than men? Or would the result have been different, if the model were a girl?

Of course, at all times of Dannick's study, the street crossings had light traffic and there were no uniformed cops in sight. It would be interesting if he found out how many would still cross the street when a policeman was around.

The dream laboratory

SHAKESPEARE, of course, called her Queen Mab, the fairies' midwife and dream-maker extraordinary, who rode on people's eyes in her hazel-nut coach and made them dream. And like Romeo, one could say, he " talkest of nothing! " What then are dreams?

Ask, Michel Jouvet of the Department of Experimental Medicine, Claude Bernard University, Lyon, France. It was Jouvet who had earlier shown that REM (Rapid Eye Movement) sleep is dream sleep — it (REM) shows if the sleeper is dreaming. Now, after years of quiet work, he has come out with a startling theory: Dreams are the *rehearsal* stage for the mind's actions. It is here, says he, that the mind practises vital behaviour patterns before the actual encounter with reality occurs.

Jouvet has been working with animals for a long time. He found all mammals and birds dream, but not the cold-blooded ones like snakes and reptiles. As long as this homoiothermic distinction exists, it means dreams are not an essential part of life itself.

But it could be essential to the brain, or its development. Jouvet found some animals (rats, mice, guinea pigs, etc) can dream even in the mother's womb. Also, four-fifths of the sleep in a new-born animal is REM sleep, but as the animal grows older, the dream content diminishes. Jouvet's work with cats showed another remarkable feature: the centre for dreaming is in the reticular formation of the pons. But this centre activates the whole brain! How then does the animal refrain from acting out the dream?

That, says Jouvet, is seen to by a motor inhibitory mechanism at the presynaptic level. If this were repressed, would the animals act out their dreams? Jouvet destroyed the mechanism in a dozen animals and found they did. And since these acts are primarily predatory or defensive, the dreams must be rehearsals for the actual wakeful acts, he concludes. Maybe this is why instinctive acts are so perfect — because they have been rehearsed. Again, since instinctive acts differ from animal to animal, could it be that dreams have a genetic origin? Well, Jouvet has already started experiments to raise animals in sensory deprivation and *without* the inhibitory mechanism. If the genetic theory is correct, then the animals' instinctive behaviour would be erratic.

What about human dreams? It would be difficult to find out, no doubt, but Jouvet plans to study people who take large doses of dream-suppressant MAO (monoamine oxidase) drugs. Those who don't dream will show — Jouvet expects — a flat, non-individualistic character.

If night dreams are rehearsals for later action, what are day-dreams then? These we are used to call the synonym of ' not-doing '!

P.P.

THE TRUTH ABOUT COOKING OILS AND VANASPATI

THE human body needs fats — for energy and for storage as future food — and the cooking media provide a large share of this requirement. Animal fats are taboo for our large vegetarian population and the place of honour goes to ghee followed by oils extracted from various oilseeds. And during the last few decades, the "common man's ghee" or vanaspati — which is nothing but hydrogenated vegetable oil — has been doing pretty well.

How much fat does a man need? Nutritionists say, 22 kg per year — at least! How much does an Indian get? In 1960-61, it was 3·5 kg of oil and 1 kg of vanaspati. Today, he gets even less: 2·3 kg of oil and 1·1 kg of vanaspati. Per year, yes! And don't take the 'averages' seriously. A recent seminar on the NCST report on oils and fats revealed that about 30 per cent of our population don't get to use any kind of fats or oils in their diet.

Why this shortage, considering that a large part of our industrial production is oilseed-based — making soaps (mostly from non-edible oils combined with edible oils) and cooking oils and vanaspati? For one thing, oilseed crops are climate-sensitive and fail miserably as it happened with groundnut which makes up 70 per cent of oilseed production. Also the acreage of oilseed production happens to be one of the most neglected areas in our agricultural planning. For another, the vanaspati industry has hardly any R & D activity to evolve alternative combinations. The result: today oils and vanaspati sell at the price of ghee!

For those who don't get it, it may be of no concern. But those who do, often have some questions to ask. Like what are oils and fats really? Are they good for the body? Harmful? Can adulteration be checked? What is the secret of vanaspati's success? How bleak is the future?

Here are some answers.

PART I

K. A. Neelakantan

Fats and oils

FATS are one of the three major food materials — proteins and carbohydrates are the other two — needed by the animal body. Fats chemically are glyceride esters of fatty acids. When solid or plastic at ordinary temperatures, we call them fats; when they are liquid, they are called oils.

Natural fats and oils come from a variety of sources — animals, plants and marine organisms. The animal fats come from the fatty tissue in animal bodies and include tallow from cattle, sheep and goats and lard from hogs. Butter and ghee too are a special type of animal fat because they are made from milk. The vegetable fats and oils are obtained from a number of plant seeds and nuts. The marine oils come from sardines, herrings, salmons, whales, dolphins, seals, porpoises, etc.

A number of natural fats and oils are non-edible (due to toxic factors) and mainly find use in various industries like soaps and detergents, textiles, paints and varnishes, leather, printing-ink, lubricants, cosmetics and pharmaceuticals.

In the Indian kitchen, animal fats hardly have a place, because a large section of the population is vegetarian. The traditional place of honour goes to ghee — despite its having an animal source — and vegetable oils. But ghee is an expensive item and the recent acute shortages of milk and milk products have made it scarce too. Today, most of our cooking is done with a substitute that looks like ghee — but is not quite ghee — made by hydrogenation of vegetable oils. We call it vanaspati.

Thus a major portion of our cooking oils has a vegetable source. In fact, all seeds contain a certain amount of food reserve — carbohydrates (starch) and fats — which is stored there while the seed is still attached to the parent plant and which later nourishes the young embryo until it can manufacture food for itself. But the stored fat content varies from seed to seed. In most, the amount is so little that extraction of oil is hardly worthwhile. Yet, there are a few, about a dozen or so, that yield enough to make them support a large oilseed-based industry.

The main criterion for any oilseed to qualify as a consumable source of oil is that it should be free from toxicity. Among the major edible oils now consumed by the population are groundnut, coconut, rape or mustard, sesame, safflower, soyabean and niger. There is a proposal to introduce corn and sunflower seed oils shortly in the country. Certain other oils like cottonseed, linseed, sal, rice bran, mowrah, etc, which are *per se* not fit for edible purposes, can be made edible after suitable processing and refining.

How the oil is extracted

THE extraction of oil from the oilseed is done by a wide variety of methods right from the primitive village ghani to the more sophisticated expeller and modern solvent extraction plants.

Proper storage of the seeds meant for extraction is important since enzymes and moisture can damage the fatty constituents. However, even under the best storage conditions, some deterioration does occur like colour degradation and increase in free fatty acids.

Before pressing, the seeds are first cleansed of foreign materials like dirt, leaves and stems by the use of sieves and air separators. Then they are decorticated, a process in which the strong hull or shell is cracked. This operation is followed by complete separation of the kernels from the shells, again by means of sieves or air separators.

Why do we need fats?

FATS in the diet serve to increase palatability and flavour of foods. They provide a lubricating action and delay the onset of hunger. They also improve the texture of food items.

The nutrient value of fats is characterised by their high energy content. They supply about 9·3 calories per gram — over twice that of proteins and carbohydrates. They also carry the essential fatty acids and fat-soluble vitamins, A, D and K, required by the human body. They are also the chief source of vitamin E.

The fats taken up by the body serve three purposes: (1) They are stored for future use as a reserve food in adipose tissues, the important depots being subcutaneous tissue, liver and intra-muscular connective tissue. (2) They combine with proteins in the formation of cellular protoplasm, cell membranes, etc. (3) They may be oxidised immediately to carbon dioxide and water. The energy thus liberated is used to produce muscular work and maintain the body temperature.

However, ingestion of too much fat (especially animal fat) is best avoided, since medical researches have shown a positive correlation between deaths from atherosclerosis (due to deposition of cholesterol in the arteries) and consumption of certain kinds of fats (see box on page 45).

The next operation is crushing, grinding or rolling of the kernels. For maximum oil recovery, it is necessary to submit the oil-bearing material to heat treatment termed cooking or conditioning to adjust the moisture content. The treatment is done in specially designed cookers and also in heated and moisture-conditioned conveyor systems.

Primitive mills and presses for the extraction of vegetable oil from oilseeds have been in use in India since ancient times. The oldest still in use is the bullock-driven village *ghani* or *chakki*. This is simply a pestle and mortar. The mortar is fixed to the ground and the pestle which is made of wood is connected to a shaft and is operated by bullocks. Rural electrification has led to the introduction of the power-driven rotary mill which is an adaptation of the ghani. In fact, the cold-pressed crude oil produced in the ghanis is still a favoured item in many households, mainly because it retains the familiar flavour and the vitamins in the original oil. Although the ghani is not a very efficient extractor, it is still a substantial employer of rural labour and saves on transportation.

Above: (left) Niger; (right) Coconut. Below: (left) palm seed; (right) sesame seed.

What the oilseeds look like...

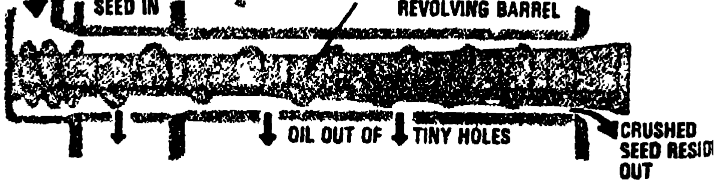
MECHANISATION CAME with the introduction of the hydraulic press by the end of the 18th century. This too was replaced by the more efficient screw press or expeller towards the end of the last century. The expeller enables continuous operation and permits a higher oil recovery than the hydraulic press. The hydraulic press being discontinuous and requiring large labour has not found much favour in the country, and most of the large factories now use expellers. The expellers employ high pressures to separate the oil from the fat-bearing material. It consists of a cylindrical cage in which a helical worm shaft moves. The cage contains openings for the drainage of the expelled oil (see diagram). The flaked and cooked material adjusted to a moisture content of 2 to 5 per cent is fed at one end and is subjected to increasing pressure by the screw which expels the cake through a constricted opening at the far end of the cage. Modern expellers can reduce the oil content in the pressed cake to about 4 to 8 per cent.

Solvent extraction now complements all other extraction methods. Several types of extractors like percolator or total immersion type are used, but most operate on a continuous counter-current principle with the flakes passing through the extractor in the opposite direction to the solvent (see diagram). The most common and efficient solvent now in use is commercial food-grade hexane, which extracts from very finely flaked seeds all but 0·5 to 1 per cent of the oil. Oilseeds containing more than 30 per cent oil are often given a prepressing treatment in expellers to reduce the oil content to 8 to 18 per cent before solvent extraction. Desolventising is a process in which the solution of oil-in-solvent called miscella is heated to recover the solvent, the last traces being removed under vacuum with steam. A single commercial extractor is capable of handling more than 100 tons of oil-bearing material per day.

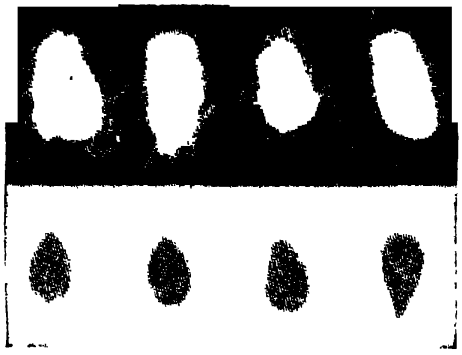
How they are extracted...

Below: The expeller process. The seed is crushed by the revolving shaft. Oil escapes through tiny slits in the barrel.

Facing page: Simplified diagram of a solvent extraction plant. The fresh, very oily seed is washed by the oiliest solvent which has already washed several lots of seed. The seed is finally washed by fresh solvent which removes the last traces of oil



Left: Sunflower and (above) fruit and seed



Right: Groundnut.
Below: Cottonseed

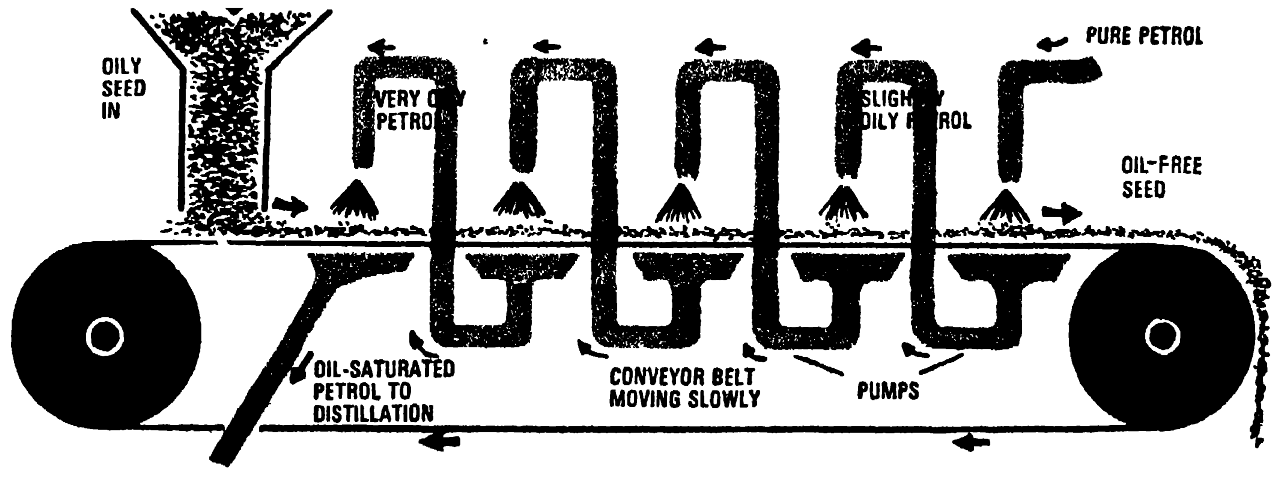
The cake obtained after the extraction of the oil is a valuable food item, and is now extensively used as an animal feed. For example, groundnut cake from the ghani is one of the cheapest oil cakes with a high nutritive value. It contains a higher proportion of protein and oil than any other oil cake, which are both easily digestible. The non-edible cakes are also used as organic manure in many states in the country.

Refining the crude oil

REFINING is the general term used to describe the overall process of purifying the extracted oil. It consists of removing the following constituents present in crude oils: (1) suspended and colloidally dissolved matter; (2) free fatty acids; (3) colour; and (4) odour.

The finely dispersed and colloidally dissolved matter — which consists mainly of proteinic and carbohydrate elements — is removed by simply allowing the oil to settle by gravity in heated tanks with conical bottoms. Often, coagulation of the colloidally dispersed matter is facilitated by heating with open steam with the aid of coagulants such as citric acid.

Alkali refining is the commercial process generally employed for the removal of free fatty acids. The process consists in mixing moderately strong solutions of caustic soda or sodium carbonate with the oil and heating the mixture rapidly to about 55°-70°C, when it forms soaps of the free fatty acids. The soapy precipitate known as " foots " or " soap stock " (as it is



mainly used in the manufacture of soap products) when allowed to settle contains foreign matter as well as an appreciable amount of the colouring constituents.

In the conventional caustic process — a continuous process — the mixture is passed through a battery of centrifuges which separate the foots from the neutral oil. The full soda ash process, a two-step process in which both a solution of soda ash and caustic soda are employed, gives excellent refined oil, but the equipment and processing are more complex. In the more recent method, known as the " miscella refining process ", the miscella from the solvent extraction process is treated with a relatively dilute caustic soda solution. The resultant foots are separated from the miscella in high speed centrifuges. The refined oil is subsequently washed free of soap in the washing centrifuge and dried under vacuum to remove moisture.

The soap stock obtained during alkali refining is used for soap making or the fatty acids are recovered from it by acidulation and distillation to be used for various purposes.

Bleaching is an adsorption process for removing colour. In this process, natural or acid-activated clays and charcoal which adsorb coloured bodies are used. Vacuum bleaching is now the preferred method. The refined oil is stirred with the adsorbents at 110°–120°C, followed by filtration through a filter press. Bleaching rapidly removes most of the yellow carotenoid pigments. Special acid-activated clays or carbon are used to remove green pigments present in some oils.

Deodorisation is the process of treating oil with steam under a high vacuum to remove traces of volatile materials which give odour or flavour. Temperatures of 200°–250°C and a vacuum of 5–6 mm are usually used in batch, semicontinuous or continuous processes. The process is applied to refined and bleached oils and hydrogenated products that are used for edible purposes.

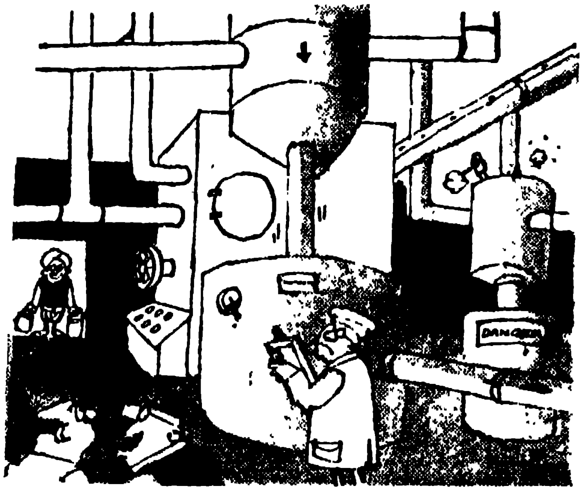
Chemical composition of fats and oils

FATS AND OILS ARE BASICALLY esters of glycerol, $C_3H_5(OH)_3$, and various fatty acids, most of which have an even number of carbon atoms arranged in a long straight chain. The natural fats are mainly triglycerides. Although it is theoretically

Soyabean

Fatty acid	Symbol	Groundnut oil I.V. 84–100 m.P. 0–3°C	Cottonseed oil I.V. 96–115 m.P. 3–4°C	Rape/mustard oil I.V. 93–124 m.P. —8 to —16°C	Safflower oil I.V. 130–150 m.P. —13 to —20°C	Sesame oil I.V. [illegible]3–116 m.P. 0 to —6°C	Soyabean oil I.V. 117–141 m.P. —8 to —18°C
Myristic	14 : 0	—	1–2	—	—	—	—
Palmitic	16 : 0	6–14	17–29	1–3	2–10	7–12	7–12
Stearic	18 : 0	2–7	1–4	1–3	1–6	3–6	2–6
Arachidic	20 : 0	1–2	—	0–2	—	—	—
Behenic	22 : 0	2–4	—	0–3	—	—	—
Lignoceric	24 : 0	1–2	—	0–2	—	—	—
Palmitoleic	16 : 1	—	0–2	—	—	—	—
Oleic	18 : 1	40–72	13–44	8–40	7–42	35–50	20–50
Linoleic	18 : 2	13–38	33–58	10–29	55–80	35–50	36–65
Linolenic	18 : 3	—	—	5–18	0–3	—	2–13
Eicosenoic	20 : 1	0–2	—	4–15	—	—	—
Erucic	22 : 1	—	—	22–60	—	—	—

Note :— Compositions less than 1 per cent have been omitted. Coconut oil contains in addition caproic acid (8
(12 : 0) — 44 to 51%.



"I am the director of this oil plant, so what? My cooking oil comes from the village ghani."

TABLE I. FATTY ACID COMPOSITION OF EDIBLE OILS AND FATS

(per cent by weight of methyl esters)

Sunflower oil I.V. 113–143 m.P. — 16 to — 19°C	Corn oil I.V. 103–130 m.P. — 10 to — 15°C	Coconut oil I.V. 7·5–10·5 m.P. 23–28°C	Lard I.V. 46–66 m.P. 28–48°C	Edible tallow I.V. 31–47 m.P. 40 to 49°C
—	—	13–18	1–3	1–8
3–10	8–19	7–11	20–32	23–37
1–10	1–4	1–3	5–18	6–30
—	—	—	—	—
—	—	—	—	—
—	—	—	—	—
—	—	—	2–5	1–6
14–72	19–50	5–8	35–62	36–50
20–75	34–62	1–3	3–16	1–5
—	—	—	0–2	—
—	—	—	—	—
—	—	—	—	—

" caprylic acid (10 : 0) — 5–10% and lauric acid

possible that the triglycerides may be simple, that is, composed of glycerol esterified three times with the same fatty acid, the general rule is that the natural fats are mixed, that is, three different fatty acids are involved with one molecule of glycerol.

The fatty acids found in the oils may be either saturated, ie, each carbon atom in the chain is linked by a single bond to other carbon atoms or to hydrogen atoms, or they may be unsaturated, having one or more carbon atoms in the chain joined by a double bond.

The most important saturated acids in edible fats are stearic (18 carbon atoms) and palmitic (16).

Oleic acid (18 carbon atoms) with a double bond in position 9 — the number of lower carbon atoms before the double bond occurs — is the most abundant unsaturated acid. The other prominent fatty acids with 2 or more double bonds include linoleic acid (18), with 2 double bonds in the 9th and 12th positions, and linolenic acid (18) with 3 double bonds in the 9th, 12th and 15th positions. The naturally occurring acids are of the *cis* form (see figure on p. 39).

BECAUSE OF THE many different fatty acids, both saturated and unsaturated, a great variety is seen in the structures of individual fats or oils. This accounts for the wide variations in their physical properties and their complex nature (see Table 1).

The natural fats also contain small amounts of non-fat components or their hydrolytic products, together known as 'unsaponifiable matter,' a term used to denote all those constituents of fats that are not saponified by a

Properties of oils

THE natural flavour and odour of oils are due to the presence of non-fatty matter. Their colour is due to the presence of small amounts of fat-soluble pigments such as carotenoids and chlorophyll or sometimes to oxidisation and polymerisation products of the fatty acids. Refined oil is nearly odourless and colourless.

The oils are insoluble in water and are poorly soluble in lower alcohols. On the other hand, they are readily soluble in ethyl ether, hydrocarbons, benzene, chloroform, carbon disulphide and the common halogenated solvents. Solvent extraction utilises this property of the oils.

The oils are graded and specified by several characteristic physical qualities such as specific gravity, refractive index, melting point, iodine value, colour, unsaponifiable matter and amount of free fatty acids.

standard alkali, and which are soluble in petroleum ether or ethyl ether. The non-glyceride matter in common oils varies approximately from 0 to 2 per cent. They include hydrocarbons, sterols, carotenoids and fat-soluble vitamins. Some fats are rich in vitamin E. The tocopherols (one of which is vitamin E) function as antioxidants and delay the development of rancidity in the fat.

Safflower

Importance of edible oils and fats in the diet

IMPROVED gas-liquid chromatographic methods have enabled the classification of oils according to their fatty acid composition. The fatty acid composition of the different edible oils and animal fats used in India is given in the Table on pages 34-35.

The importance of polyunsaturated fatty acids (PUFA) in the diet is now well recognised. They are reported to possess the property of lowering abnormally high cholesterol levels in blood vessels, and are recommended for patients with a high risk of coronary artery diseases. These acids, in the form of lipoproteins, serve mainly in the formation of cell membranes and connective tissue. Deficiency of these fatty acids has been suspected to play an important role besides coronary disease in diabetes mellitus, collagen diseases, bronchial asthma, kidney disorders, rheumatoid arthritis and certain skin diseases like eczema.

As is evident from the table, the animal fats — lard and tallow — are rich in the saturated fatty acids, palmitic and stearic, though they contain a large proportion of oleic acid too. In contrast, most of the vegetable seed oils are rich in oleic and linoleic acids.

Linoleic acid, not naturally synthesised in the body, plays a very important role. It has a structure best suited to the synthesis of prostaglandins, the wonder substances found in many body organs and having a profound influence on various body functions. In fact, some recent researches indicate that linoleic acid is the main precursor for the synthesis of prostaglandins.

Sunflower seed oil, soyabean oil, safflower and sesame seed oils are rich sources, and groundnut, cottonseed and corn oils good sources of polyunsaturated fatty acids. Modern nutritionists, therefore, recommend a diet rich in vegetable oils and low in animal fat, while keeping the total calories intake constant.

Coconut oil is a poor source of polyunsaturated fatty acids. Like other palm oils, it is characterised by high percentages of myristic, lauric and saturated fatty acids containing a still lower number of carbon atoms. The rape/mustard oil is unique in composition when compared with other vegetable oils. It contains a high proportion of erucic acid, $C_{22}H_{42}O_2$, with a single double bond in the 13th position, followed by oleic and linoleic acids. The saturated acids — palmitic and stearic — are present in very small proportions.

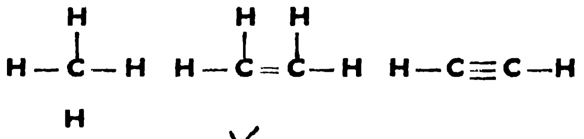
Basic chemistry and definitions

FATTY ACIDS: They are monocarboxylic acids having the general formula R. COOH, where R is hydrogen or a group of carbon and hydrogen atoms, and COOH is the carboxylic group.

GLYCERIDES: These are esters of glycerol $C_3H_5(OH)_3$ with organic acids. Animal and vegetable fats and oils are mainly composed of triglycerides of fatty acids, such as stearic, palmitic, oleic, linoleic, etc.

VALENCY BONDS: The capacity of an atom to combine with other atoms to form a molecule is known as its valency. It is also the number of hydrogen atoms which an atom will combine with or replace. For example, the valency of oxygen in water (H_2O) is 2. The valency of carbon is 4. The valency of an atom can be explained on the basis of the modern electronic theory of atomic structure, and particularly on the assumption that certain arrangements of outer electrons in atoms (octets or outer shells of 8 electrons) are stable and tend to be formed by the transfer or sharing of electrons between atoms.

The link holding together atoms in a molecule is called a valency bond. It is possible for an atom in a compound to satisfy one, two or multiple valency bonds of another atom, giving rise to single, double or multiple bonds. Thus carbon forms single bonds with hydrogen in methane, a *double-bond* in ethylene and *triple-bond* in acetylene.



$$\begin{array}{c}H\\|\\H-C-H\\|\\H\end{array}\qquad\begin{array}{c}H\ \ \ H\\|\ \ \ \ |\\H-C=C-H\end{array}\qquad H-C\equiv C-H$$

Methane (CH_4) ~~M~~Ethylene (C_2H_4) Acetylene (C_2H_2)

UNSATURATED COMPOUND: A compound (fatty acid) having some of the atoms in its molecule linked by double or multiple bonds; a compound which can form additional compounds.

SATURATED COMPOUND: A compound (fatty acid) the molecule of which contains no double or multiple valency bonds between the atoms; it does not form additional compounds.

ISOMERISM: Two or more chemical compounds with the same molecular formula but having different properties owing to a different arrangement of atoms within the molecule are called isomers.

IODINE VALUE: A measure of the total amount of unsaturation present in a sample of fat or oil or other natural products. It is determined by the weight of iodine absorbed by 100 gm of the substance. The higher the iodine value, the less is the percentage of saturated fatty acids.

Keeping quality of oils

THE refined and purified oil should have a fairly long keeping quality. However, oils get spoilt in storage due to various spoilage factors. The main one is oxidation.

Auto-oxidation gives rise to the characteristic off flavours of various edible oils. Flavour stability depends on the degree and type of unsaturation in an oil. Oxygen from the air first reacts with the unsaturated fatty acids without saturating the double bonds to form hydroperoxides which then decompose to aldehydes and ketones which contribute to the off flavour and bad odour. Therefore, oils containing fatty acids with many double bonds have a poor flavour stability. On the other hand, oils containing a high proportion of saturated acids are less subject to oxidative deterioration.

Auto-oxidation is catalysed by light and metals such as copper or iron and like most reactions is accelerated by heat. Citric acid is often added during processing to inactivate these trace metals. To prevent oxidation, packing the refined oil in metal containers under nitrogen, an inert gas, is, therefore, a standard practice. Antioxidants such as nordihydroguaiaretic acid (NDGA), butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are largely used abroad to control rancidity in fats deficient in naturally occurring antioxidants, and their importance is now being recognised in this country. Legislation demands declaration of the use of these substances on the label attached to the packed tin.

What is vanaspati?

VANASPATI is nothing but hydrogenated edible vegetable oil. The process of hydrogenation modifies the composition and properties of oils. In fact, it converts the liquid oils into a plastic fat, giving at the same time the product a texture acceptable to the consumer.

In India since time immemorial ghee has been used for the preparation of sweets, since sweetmeats prepared in ghee have longer shelf-life and a characteristic flavour. Vanaspati is designed to imitate ghee by making use of vegetable oils.

The first phenomenal success of an imitation product in human diet was achieved by margarine, a substitute for butter. In the United States and some other western countries, the production of margarine has far outstripped that of butter. The success of margarine has led to the preparation of a wide variety of vegetable shortenings.

TABLE 2. WHERE THE EDIBLE OILSEEDS COME FROM

Oilseed	Botanical name	Crop season	Major states where grown	Area* (1,000 hectares)	Production* (1,000 tonnes)	Yield* (Kg/ hectare)
Groundnut	Arachis hypogaea	Kharif 4-5 months	Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh	7,290	6,065	835
Rape and mustard	Brassica sarson, B. toria, B. Rai	Rabi 4-5 months	Punjab, UP, Bihar, Bengal and Assam	3,330	1,960	590
Coconut	Cocos nucifera	Perennial	Kerala, Mysore, Tamil Nadu, Andhra Pradesh	1,046	608	57[illegible]
Sesame	Sesamum indicum	Kharif 4-5 months	All states except Assam, Jammu & Kashmir	—	—	—
Niger	Guizotia abyssinica	Kharif 4-6 months	Madhya Pradesh, Orissa, Andhra Pradesh, Maharashtra and Mysore	—	—	—
Soyabean	Glycine max	Kharif 5-7 months	Assam, Bengal, Manipur, Meghalaya and Nagaland	30	—	—
Sunflower	Helianthus annus	Annual	Grown as a garden plant	—	—	—

* The area, production and yeild are given for the year 1970-71.

Sunflower has been recently introduced under experimental conditions. Total area under cultivation during 1972-73 was 116,000 hectares. This will be increased to 320,000 hectares by next year.

Rapeseed

Hydrogenation of oils

INDUSTRIAL hydrogenation is a process to produce harder fats from soft oils which are in comparative abundance. The process may be said to have started with the demonstration by Sabatier in 1897 that finely-divided nickel has the ability to cause gaseous hydrogen, and a gaseous unsaturated hydrocarbon to combine, forming the corresponding saturated hydrocarbon. Normann in 1903 showed that an oil in the liquid phase can also be converted into a solid fat by the action of gaseous hydrogen in the presence of a solid catalyst. Initially it was assumed that simple conversion of unsaturated fatty acids of the oil into saturated ones was all that happened, but now it is known that the whole process is exceedingly complex. The reactions involved are still not fully understood, and work on elucidating the reaction mechanisms under various conditions is still going on all over the world.

For fat hydrogenation, nickel has been the most important catalyst from the very beginning, though platinum and palladium can also be used. Recently, the use of copper has been recommended for the hydrogenation of soyabean oil. The catalysts have the property of accommodating hydrogen atoms temporarily and releasing them subsequently. They also have the ability to activate the hydrogen and the unsaturated molecules by the formation of intermediate complexes. For solid catalysts, the formation of the intermediates is called adsorption.

The nature of the catalyst surface is very important in the process. Obviously, a finely-divided catalyst with a large surface area will be more effective than a coarse one. But this is not all. Heterogeneity of the surface is as important as surface area and this is achieved by bringing the catalyst into a state of extreme sub-division (by procedures such as precipitation of nickel salt solutions using hydrogen or an alkali solution or metal hydrides) or by the use of catalyst supports which further serve to disperse the catalyst and achieve wider contact of the oil with the catalyst surface. Today, there is growing evidence that on almost all catalytic surfaces, different types of active centres occur, and these are specific to certain adsorptions or types of reactions.

The nickel surface dissociates the molecule of hydrogen into hydrogen atoms as well as absorbs the unsaturated compound. The transient intermediate formed by the combination of the two may add another hydrogen atom to give a saturated product, or lose a hydrogen atom to give a double-bond either of the *cis* or of the *trans* configuration. Thus, this half-hydrogenation mechanism leads to isomerisation.

IN COMMERCIAL hydrogenation, it is observed that fatty acids with both single and two or more double bonds undergo transformation. However, fatty acids with a single double bond like oleic acid are hydrogenated more slowly or at a later stage than others like linoleic and linolenic acids with two and three double bonds respectively. Also hydrogenation of a polyunsaturated chain once started tends to stop or slow down considerably on reaching the single double-bond stage. This is believed to be due to the selective adsorption of the more unsaturated fatty acids on the catalyst surface.

Several reactions, in fact, occur during the hydrogenation of oil containing unsaturated fatty acids—simple saturation of oleic and linoleic acids to stearic acid, or half-saturation of linoleic acid to yield 9- or 12- oleic acid. Migration of double bonds occurs extensively, either in oleic, or in half-saturated linoleic, or in linoleic acid itself. Such migration of double bonds is often accompanied by a change in the configuration of the double bonds from *cis* to *trans*, which is the form of lower energy.

It is now understood that for any particular oil being hydrogenated, the entire reaction is controlled mainly by the hydrogen available on the catalyst surface. Increased hydrogen pressure means more surface hydrogen, more direct saturation and poor selectivity. Low hydrogen pressure gives less chance of saturation, and, hence, high selectivity and high *trans* isomer formation. Hence, the hydrogen pressure, temperature and agitation are the main parameters controlled to obtain a certain degree of hydrogenation.

Under certain extreme conditions during catalytic hydrogenation of oils containing polyunsaturated fatty acids, undesirable products containing a ring structure, such as benzene monocarboxylic acids can be formed in significant amounts. The possibility of these side-reactions increases progressively with the degree of unsaturation of the oil to be processed. The side reactions are, however, prevented by maintaining an adequate hydrogen pressure and a good hydrogen dispersion in the oil in the initial stages, as well as operating at a lower temperature.

Hydrogenation of groundnut oil under industrial conditions has been extensively studied in India, and will serve to illustrate the reactions mentioned above. For the manufacture of vanaspati, the oil is hydrogenated at about 180°C under low agitation with hydrogen at comparatively low pressure (30-35 psi) using very small amounts of nickel catalyst (0·02-0·1%), generally in the form of the metal precipitated from a nickel compound (carbonate, formate, carbonyl) on to a carrier.

The composition of the fatty acids and the iodine value of the original groundnut oil and the manufactured vanaspati are as follows:

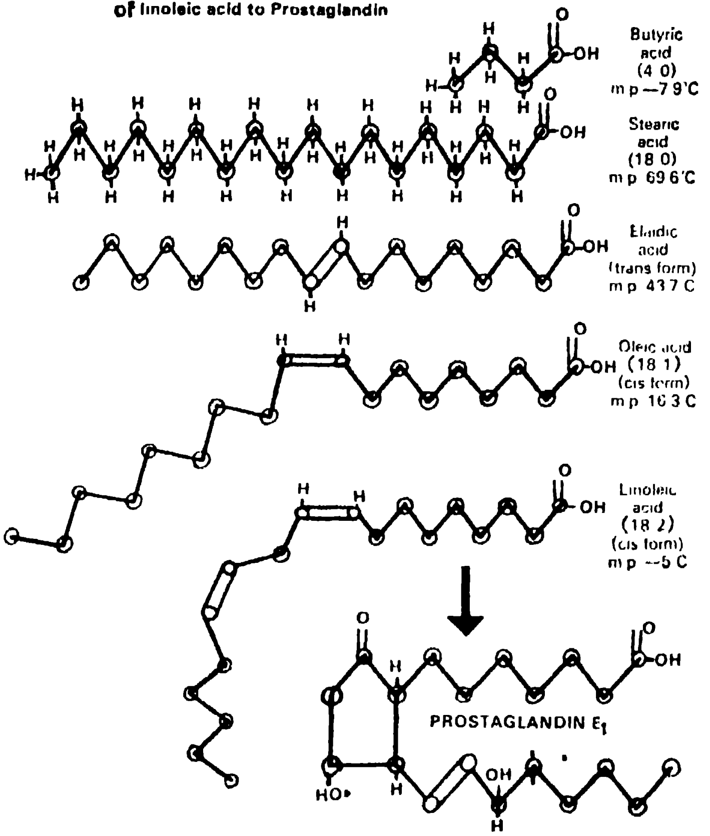
	Groundnut oil	*Vanaspati*
Iodine value	92	67-70
Total saturated	20%	25%
Oleic (*cis* monoene)	55%	35%
Linoleic	25%	5%
Trans monoene	nil	35%

Two changes mainly occur: the conversion of 20 per cent of linoleic acid to *trans* single bond (monoenoic) acids, and the transformation of 15 per cent of *cis* monoenoic (oleic) acid also to *trans* monoenoic acids. Very little additional saturated acids are produced. Since several of the *trans* monoene acids have melting points of about 44°C, the overall melting point of the vanaspati produced is raised to the desired level of 37°C. The solid fat melts fully and easily on the tongue at this melting point, and does not leave a greasy feel.

The linoleic acid content has fallen markedly, while the monoenoic acids have not been saturated to any great extent: this is therefore a selective hydrogenation directed to reduction of linoleic acid. The formation of *trans* isomers is irrelevant to the selectivity concept, and is superimposed on it. The conditions of hydrogenation are, in fact, chosen to facilitate both selectivity and *trans* monoene formation.

K. T. Achaya

Structure of fatty acids and the resemblance of linoleic acid to Prostaglandin


Butyric acid (4 0) m p −7 9°C
Stearic acid (18 0) m p 69 6°C
Elaidic acid (trans form) m p 43 7 C
Oleic acid (18 1) (cis form) m p 16 3 C
Linoleic acid (18 2) (cis form) m p −5 C
PROSTAGLANDIN E1
H
O
OH
HO

Cis-trans isomerism is associated with compounds containing one or more double bonds. For example, oleic acid and elaidic acid are respectively *cis* and *trans* forms. The *trans* acids have a higher melting point than the *cis* acids, since a *trans* double bond causes only a slight kink in the linearity of the fatty acid, and the molecules can, therefore, pack tightly together, as do saturated acids of high melting point. A *cis* double bond causes a big bend in the molecule, leading to less dense packing and, hence, low melting points.

The *cis-cis* form of linoleic acid is finally converted to prostaglandins in the body. Note the similarity of structure of the bent linoleic acid in the natural form and prostaglandin E1.

Vanaspati was introduced in India from Europe after the First World War and it found an immediate and immense popularity. The growth of the vanaspati industry since then is amply demonstrated by the increasing amounts of vegetable oils that go into its production year after year.

HYDROGENATION not only brings about a dramatic change in the melting point, but also drastically improves the stability of the oils used towards oxidative rancidity. Both these are achieved by converting unsaturated fatty acids to saturated fatty acids, and *cis* double bonds to *trans* form, which is essentially a side-effect of the process.

Hydrogenation of oils with saturation of all double bonds would lead to a product with melting point around 60°C, which would be of no use for human consumption. Hence, hydrogenation for edible purposes is always partial and selective.

In the case of vanaspati manufacture, the hydrogenation is conducted under selective conditions to get a product (max. m.p. 31°–37°C) with the texture of ghee and which would melt like ghee when placed on the tongue.

A food item prepared using vanaspati retains its crispness and freshness for a longer time when compared to cooking oil due to the improved resistance to oxidation and less penetration of moisture through the fat film.

TABLE 3. CONSUMPTION OF OILS BY THE VANASPATI INDUSTRY

(Thousand tonnes)

	1968		1969		1970		1971		1972		1973 (Jan.-May)	
	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%	Qty	%
Groundnut	313	65·4	257	52·7	323	59·5	402	65·3	358	57·3	59	30·0
Cottonseed	28	5·9	33	6·8	93	17·1	76	12·4	135	21·6	76	38·6
Sesame	72	15·1	89	18·2	40	7·4	36	5·9	41	6·6	15	7·6
Soyabean (imported) ..	65	13·6	108	22·3	87	16·0	101	16·4	76	12·1	32	16·2
Safflower	—	—	—	—	—	—	—	—	15	2·4	15	7·6
Total	478		487		543		615		625		197	

(Courtesy : *Economic Times*, 26 July, 1973)

IT IS, HOWEVER, now the view of nutritional experts that excessive levels of saturated fatty acids are undesirable. Further, there are indications that the *trans* forms of the fatty acids are biologically inert and may even serve as antagonists. Though in the manufacture of vanaspati, selective hydrogenation prevents the formation of excessive amounts of saturated fatty acids, a large proportion of the linoleic acid, the most important of the essential fatty acids, is present as the *trans* form in the final product.

This is why the Government of India has made it mandatory since April 1972, under the Essential Commodities Act to blend vanaspati with 2·5 per cent safflower and 7·5 per cent sesame oils so that the content of polyunsaturated

How safe is rape or mustard oil?

RAPE and mustard oils are consumed in northern India, especially in Bengal. Mustard oil is peculiar in its fatty acid composition, since it contains a high proportion of erucic acid. Nutritional experiments being conducted on animals for the past two decades are providing increasing evidence that the erucic acid in mustard oil produces various effects such as growth retardation and altered cholesterol metabolism. It has also been found that the food intake of the animals taking rapeseed oil was less (while their life-span was 20 to 25 per cent longer) than that of the control animals. However, when fed considerable amounts of rapeseed oil, a large number of experimental animals died.

The most damaging evidence, however, is recent experiments on monkeys which indicate that erucic acid is responsible for myocardial fibrosis in them. These experiments have created such a scare in Canada, one of the leading producers of rapeseeds, that they have now developed strains of Brassica which give seeds with an erucic acid content of about 7 per cent. One of the interesting investigations that could be carried out in India would be to find out how far the consumption of mustard oil has affected the Bengali population; they have been consuming this oil for generations.

Mustard oil is often contaminated with argemone oil, another poison. The contamination is not always wilful, since the seeds of *Argemone Mexicana* Linn which grow along with Brassica get mixed with the mustard seeds. Argemone oil contains an alkaloid, sanguinarine, which in high doses produces a disease known as epidemic dropsy, characterised by fluid accumulation in the lower extremities and oedema. There is evidence from animal experiments that argemone oil also raises eye tension and atrophy of the optic nerves. Damage of the visual field has, in fact, been observed in patients with epidemic dropsy.

It is easy to detect argemone oil in mustard oil. When a sample of the oil is shaken with an equal volume of nitric acid, it should not develop a brownish red or orange colour, if argemone oil is absent. Trace quantities of argemone oil can also be detected by chromatographic methods. The present methods of detection can detect up to 0·1 per cent of argemone oil contamination in edible oils. This amount contains less than 0·35 ng of sanguinarine and has not been shown to be toxic or otherwise harmful to humans. The oil trade is now well aware of this problem, and all oils containing even minute amounts of argemone oil are not used for processing.

* *

Do you eat samosas and bhajias regularly from shops where the oil is continuously being heated? Then, beware! Oils and fats subjected to continuous heating undergo nutritional impairment because of the formation of hydroperoxides, epoxides, polymers and some cyclic products. Experiments on animals have indicated that certain oxidised and heated fats produce growth retardation and serious pathological changes at the cellular and sub-cellular levels and alteration in membrane permeability. They also produce hepatic changes and in some cases carcinogenic properties have been ascribed to thermally degraded fats.

K.A.N.

Adulteration of oils

HOW pure is the edible oil or vanaspati you buy in the market? If purchased in sealed tins and produced by reputed manufacturers with adequate quality control and laboratory facilities, the chances are that you are getting a wholesome product for your money. On the other hand, if the oil is purchased from open containers, the probability is very high that it is adulterated. Adulteration is so rampant in our country (due to the difficulty of covering adequately the many retail shops and the problem of detecting clever adulteration even in a laboratory) that it will be your good fortune if any particular oil you buy from open containers or even in some of the improperly sealed containers is not adulterated.

Usually, a more expensive oil is adulterated with a cheaper oil. For example, large quantities of groundnut oil are used for adulterating edible oils such as gingelly (til), rape or mustard. Coconut oil is often adulterated with groundnut oil and even mineral oils, with synthetic coconut essence added to give the flavour. Sometimes even non-edible oils like castor oil, linseed oil and kusum oil are used as adulterants. Kusum oil is highly toxic for human consumption, since it contains cyanogenic compounds. Vanaspati is often adulterated with hydrogenated linseed oil and sal fat. In turn, vanaspati is used for adulterating ghee.

The most commonly used adulterant is mineral or white oil as it is popularly called. Large quantities of these, manufactured fatty acids, especially linoleic acid in the *cis* form, in the product sold to the consumer is raised. Manufacturers are also permitted to add vitamin A, 25 international units per gram, and vitamin D. The addition of sesame oil permits the detection of any vanaspati used as an adulterant in ghee.

Originally, vanaspati was manufactured in the country only from expeller groundnut oil. These days cottonseed, mustard, soyabean, safflower, sunflower and sesame oils — even if solvent extracted — are used. Utilisation of different edible oils by the vanaspati industry in the past few years is given in the table on page 39.

Dr. Neelakantan, who wrote on Milk in our September 1973 issue, is a scientist with the Tata Institute of Fundamental Research, Bombay.

How bad oils get in

The fair price shops did sell groundnut oil before Divali, but the experience of most of the consumers was that it was anything but pure groundnut oil. It was adulterated with cottonseed oil and sold by the Government agency.

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In a situation where supplies are meagre, pooling of oil and chanelling it through ration shops will help equitable distribution. However, there could be some dangers too. Unscrupulous members contributing to the pool find it a convenient way to get rid of their 'bad' oils, supported by improper certificates of test. And once the oil is mixed in the pool, it would be difficult to trace the offending contributor.

Since the oils are sold loose, it would also be difficult to trace an offending ration shop owner, if he were to adulterate the oil unless a strict check is kept by testing occasional spot samples. The buyer is thus left unprotected. The only recourse he has is to examine the oil and refuse to buy suspected oil.

and vanaspati

ostensibly for pharmaceutical purposes, find their way into good edible oils while the cheaper lubricating oils are used to adulterate the unrefined or raw oils.

Methods are available for the detection of the adulterants, and most of the classic ones depend on a change in colour. Recently, chromatographic methods are increasingly being used for the detection of trace amounts of adulterants. Some of the specific tests for detecting adulteration are given below:

Groundnut oil: The test makes use of the insolubility of the higher saturated acids (arachidic, behenic and lignoceric) present in groundnut oil. A measured amount of the sample is first saponified with alcoholic alkali and neutralised with 33 per cent acetic acid. The clear liquid is then gradually cooled under specified conditions. The appearance of quick turbidity on the crystallisation of fatty acids denotes the presence of the oil. The test is known as the Bellier Test.

Cottonseed oil: This is detected by the Halphen Test. A sample of the oil is boiled with an equal volume of butyl (or a mixture of amyl and ethyl) alcohol. An equal amount of carbon disulphide containing 2 per cent of free sulphur is then added to the hot solution of the oil. After the excess of carbon disulphide has been evaporated on a water bath, the mixture is heated for at least 20 minutes in a bath of boiling concentrated salt brine. A characteristic red or orange colouration develops in the presence of as little as 1 per cent cottonseed oil. The hydrogenated oil does not respond to this test.

Sesame oil: The test known as the Baudouin test depends on the presence of two non-glyceride components in the oil, sesamin and sesamolin. A sample of the oil is boiled with concentrated hydrochloric acid. The appearance of a pink colour on addition of a few drops of alcoholic furfural indicates the presence of sesame oil.

Linseed oil: The linolenic acid in the oil forms hexabromides when treated with bromine; this hexabromide is largely insoluble in ethyl ether and, hence, forms a means of detection.

Castor oil: The test makes use of the high content of ricinoleic acid in the glycerides. When the sample is treated with acidic ammonium molybdate, a yellow colour develops. When the oil is subjected to appropriate thin-layer chromatography, a slow-moving component is observed.

These laboratory tests vary in sensitivity but generally can detect about 5 per cent of adulteration. Tests which the housewife can use in the home are desirable, but because of the similar nature of all oils and fats, are not likely to be achieved. Many so-called traditional methods (colour, smell, spreadability on paper, granulation, etc), especially for determining the purity of ghee, have not been substantiated by scientific study. It is deterrent punishment, the growth of social conscience, and greater abundance, which will ultimately lessen the evil of adulteration.

K. T. Achaya

PART II

HOW BLEAK IS THE FUTURE?

Despite massive inputs in agricultural research, there have been no improvement in oilseeds. The per hectare yields of oilseeds in India is very low — about 800 kg in groundnut against 1,480 kg in Pakistan and 1,980 kg in USA ; about 400 kg in rapeseed against the world average of 630 kg. How can this yield be raised ?

DR. S. S. RAJAN: So far as oilseeds are concerned, inputs in agricultural research have not been " massive ". Oilseed crops (excluding coconut) now cover 16 million hectares annually. They produce 8·5 million tons of oilseeds valued at Rs. 1,200 crores — nearly 9 per cent of our total agricultural produce.

For this magnitude, what are the inputs in agricultural research and development ? In 1947-48, this was only Rs. 40,000. By 1972-73, this rose to nearly Rs. 1·3 crores. Though the increase might appear impressive, it compares very unfavourably with the overall R & D expenditure in the country which was 0·48 per cent of the gross national product (GNP) in 1970-71 and 0·54 per cent in 1971-72. The allocation for R & D in agriculture is only 0·1 per cent of the GNP. Thus oilseeds crops as also other agricultural crops receive very little attention. By no means the inputs are " massive ".

The second part of the question is very true. Per hectare yields of oilseeds in India are very low. The figures are nearly correct, though the groundnut yield in Pakistan is not perhaps as high as stated. The average groundnut yield in India during the 40s was as high as 1000 kg of pods per hectare. Over the last 30 years, this has dropped to 700 kg per hectare and has shown a slight tendency to rise in the past few years. The reason is: there has been a tremendous increase in the domestic demands which has spread groundnut cultivation to unproductive marginal areas subject to water and nutritional stress Thus, although the overall area and production (which has increased more than 100 per cent in this 30-year period) has gone up, the per hectare yield has declined. This is true of other oilseeds also, except castor.

The answer is quite apparent: raise groundnut cultivation to one of advanced agronomy. It may even be necessary to restrict cultivation of groundnut to productive areas and seasons. The average yields of Tamil Nadu and Punjab are over a ton per hectare. The summer irrigated crops of groundnut in south and central India are substantially higher than the *kharif* rain-fed crops. This basically depends on the agricultural economy of a particular region. The most important consideration is the cultivator's capacity to invest in the inputs required or the credit facilities available to him. The costliest primary input in groundnut cultivation is the seed. If the cultivator wants to use an improved variety, he may have to invest nearly Rs. 200 per hectare. Even if he is prepared to do so, he may not find the seeds of recently evolved, improved varieties since no organised largescale seed production programme is currently operating.

The agricultural technology (in the shape of high-yielding varieties, agronomic practices, plant protection measures, etc) to raise a 3-ton groundnut crop in irrigated and assured rainfall areas and a one-ton crop in the rain-fed or water-stress area is now available in the country. Groundnut yield can be raised by applying this technology extensively to the maximum possible area. This has been done in other oilseed crops. For instance, in rapeseed-mustard, the average yield was around 380 kg/hectare in the 50s. In the 70s, it rose to 466 kg/ha — an increase of 20 per cent. Considering that the area involved is as large as 3 million hectares, this is no mean achievement. This is mainly due to the extensive application of plant protection measures. Similarly, in castor, the yield has gone up from 186 kg/ha in 1950 to 345 kg/ha in 1972, mainly due to the use of new varieties and hybrids like *Aruna* or GCH-3. But all this advance is totally eclipsed by the poor performance of groundnut over the years, which itself raises an important question whether we should be so dependent on one crop in our vegetable fat economy.

One point, however, should be mentioned. It serves no purpose to compare our yields with those of other countries. The agricultural systems are entirely different. Apart from the input-intensive nature of foreign agriculture against the stress-intensive nature of our agriculture, the growing

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periods in India are shorter, and mixed and multiple cropping are common. Long rotations are not practised here due to the pressure on land. Thus the comparison should be on the basis of productivity from a unit of land, in a unit of time, for a unit of water. If so done, we do not compare badly. Our main problem is the population growth.

Seventy per cent of the total oilseed production of over 8 million tons comes from groundnut alone. And a fall in groundnut production this year has badly hit the vanaspati industry. Would it be advisable to continue with this policy ?

DR. RAJAN: No. The current strategy is to divest the vegetable fat economy of its dependency on groundnut, and make the vegetable oil resources broad-based. It is here that crops like sunflower and soyabean have a dominant role to play. Yet, it is neither feasible nor desirable to replace groundnut in the 7 million hectares that is annually planted with some other oilseed crop. Besides, groundnut has an important place in the Indian agricultural system. Only we must remove the instabilities in its production. Nor is it desirable to impose a strictly pre-determined pattern of cropping on the cultivator. What we need is a " cafeteria " approach, indicating to the farmer the several options available.

For instance, in Andhra Pradesh the farmer can be told that if the monsoon is delayed, he might plant sunflower instead of groundnut. Delayed groundnut planting reduces the yield, while sunflower planted August onwards assures reasonably good yields. But the farmer should be given sunflower seeds (which are not required in big quantities since the seed rate is low, only 4 kg per acre) and the necessary techniques of cultivation which are quite simple. On the other hand, the area under groundnut with irrigation during summer, particularly under the Project areas, should be increased since the productivity in these areas is high. We might peg the area under groundnut at the present levels and may have to repattern it considerably and keep it flexible to suit seasonal variations.

After intensive efforts to grow soyabean in India, the campaign seems to have failed. What are the reasons ? Why was so much importance given to soyabean when it is primarily a protein source more than an oil source?

DR. RAJAN: If we develop adequate means of protein utilisation, then the soyabean crop can be remunerative enough to be a success. Though soyabean is primarily a protein-yielding crop, it is the world's main oilseed crop if we take area and production of seed and oil into consideration. The prices offered currently are not attractive to the cultivator. Soyabean cannot be crushed in traditional *ghanis* for oil extraction; oil recovery is also low, since the oil content itself is not more than 20 per cent. The investment in seed is very high mainly due to defective germination and diseases. Suitable varieties are yet to be developed for central and southern regions. All these add to the cost of cultivation. If the prices are not remunerative, naturally the cultivator shows a disinclination to grow the crop.

An educative programme for the increased utilisation of soyabean protein for human consumption is very badly needed. This is not easy in a society with strong traditional preferences in food habits. Further, soyabean protein needs to be processed before being used. Very little of India's food passes through commercial channels where such efficient utilisation is possible. Smallscale home preparation with soyabean protein is yet to find acceptability. The only avenue appears to be the national nutritional feeding programmes for children that are being envisaged. With greater efforts for protein utilisation and marketing soyabean products, it should be advisable to continue our soyabean cultivation.

It is now proposed to promote sunflower as one of the major oilseeds. How is sunflower better than other oilseeds ?

DR. RAJAN: Sunflower is an important component in diversifying vegetable oil resources. Its advantages are: (*i*) being a photo-insensitive crop, it can be raised in any part of the year, provided minimal water requirements are available; (*ii*) being a short-duration crop, it can be well fitted into a multiple cropping programme (there are varieties which can mature in 85-90 days); (*iii*) the high oil content (45-48 per cent) results in a high oil yield per unit area, per unit time, per unit water quantity. Commercial extraction is nearly 33 per cent compared to 25 per cent for groundnut pods, and the oil can be pressed even in village *ghanis*; (*iv*) the cake can be utilised as cattle, poultry or human feed; (*v*) the oil with high PUFA (polyunsaturated fatty acid) content is nutritionally better than groundnut or mustard oil, and is comparable to safflower oil; and (*vi*) sunflower oil can easily blend with other edible oils.

The main disadvantages are: (*i*) production of different varieties of seeds must be on a well-organised basis as inferior seeds might reduce the oil content, the most marked trait over other oilseeds; (*ii*) considerable research is still needed to identify the optimum area and season; (*iii*) there is at present a high degree of empty or partially filled seeds and this problem has to be solved; (*iv*) the marketing is yet to be well organised, and if not done timely, might discourage the farmers; (*v*) new diseases and pests not damaging the crop in the temperate regions are likely to be a menace and have to be combated; (*vi*) considerable damage now being done by birds has to be avoided (small patches are more prone to damage than larger ones); and (*vii*) demonstrations and extension efforts should be continued at least for three seasons till the cultivator gets familiar with the techniques of cultivation.

The potential is indeed very high. There are now about 80,000 hectares under this crop and it is hoped that by the end of the Fifth Plan, the area will be doubled or even trebled. By then, the impact of sunflower production on the oil availability is expected to be substantial.

The total demand for vegetable oils in the country for 1975-76 has been projected at 4 million tons against 2·5 million tonnes in 1970-71. This would need an oilseed production of 13 to 14 million tons. How are we going to achieve this ? How long do you think will the oil shortage persist?

DR. RAJAN: A demand of 4 million tons of oil should be met by a production of at least 12 million tons of oilseeds by 1975-76. Even if given the most favourable monsoon, which is a crucial factor, it is obvious that this target cannot be met by 1975-76. The gap has obviously to be filled by imports. On the other hand, it will be more appropriate to have a long-term target and start the programme now.

It should be noted that our shortfall is only 10 per cent. Assuming that a major effort will be towards the fuller utilisation of cottonseed, the necessary infrastructure to crush the 2·6 million tons of seed produced annually must be built immediately. This might imply a ban on the sale of cottonseed by the ginneries directly, or even linking up the ginneries with cottonseed crushers. It may even be required to repattern the location of crushing units with reference to cottonseed production. Out of the 74 crushing units in the country, 26 are in Maharashtra which produce only 330,200 tons of cottonseed, while Punjab and Haryana with a production of 506,500 tons of cottonseed have only 2 units with a production capacity of 32,500 tons annually.

Obviously, crushing capacity in the Punjab-Haryana region should be increased immediately. This is given here only as an example; there are several such decisions to be taken at research, developmental, administrative and fiscal levels. The point I am trying to emphasise is that we should stop *ad hocism* in our oilseeds development planning and work for long-range targets even providing for a cushion to mitigate the vagaries of the monsoon on which the oilseed economy is so dependent. If done properly, there is no reason why the 1980s should not see us in a comfortable position.

What should be the long-term policy for meeting our requirements of edible oils?

DR. RAJAN: First, we must recognise that our own internal resources are adequate to meet our needs, both edible and industrial. We have even an export potential, particularly oils like safflower and sunflower which are vitally important in the currently quality-based world demands for edible oils. Long-term measures at research, developmental, administrative and fiscal levels to exploit these should be initiated. Some of these are: (*i*) a fuller and more complete utilisation of cottonseed and rice bran oils for edible purposes, including hydrogenation. This alone will eliminate the current deficits of edible oil; (*ii*) utilise vegetable oils of tree origin for industrial purposes like soaps and confectionary; (*iii*) increase the indigenous production of synthetic detergents which are petroleum-based; (*iv*) increase the market value of oilseeds by utilising the oilseed cake for human consumption and animal feed, thereby raising the level of oilseed cultivation to one of advanced agronomy and consequently higher productivity; and (*v*) organise the marketing of oilseeds in such a way that the producer gets the maximum returns on his investments. The lack of this now is a great disincentive to the producer in using advanced methods.

The vanaspati industry has been finding difficulty in hydrogenating the imported rapeseed and palm oils. Lack of correct techniques has also resulted in poor appearance of the finished product recently. Do we have the technology in this area?

DR. D. REBELLO: The isothiocyanates and oxazolidinethiones in rapeseed oil are not only objectionable in refining the oil but also function as poisons for nickel catalysts in hydrogenation. The catalyst is deactivated in proportion to the amount of sulphur present in the oil. Even as little as 0·016 parts per million (ppm) of sulphur reduces the catalytic activity by about 50 per cent. Also, the addition of 6 ppm phosphorus as rapeseed lecithin affects hydrogenation; this effect dominates sulphur poisoning in rapeseed oil. The decomposition products of the sulphur compounds, extracted together with the oil, are not fully removed by alkali refining or bleaching. One alternative for speedier hydrogenation is to treat the oil initially with a small amount of catalyst at 150°-200°C together with a slow flow of hydrogen. A spent catalyst could serve the purpose. Deodorisation is another way to remove the sulphur compounds which are volatile. These could also be removed if bleaching is done under vacuum.

In palm oil, the main problem is selective cooling. The palm oil fraction in the vanaspati cools first and this solidified mass tends to separate from the rest of the product, giving a liquid-solid separation. However, know-how is available in the country to reduce this tendency.

Should vanaspati be coloured?

DR. K. T. ACHAYA: Vanaspati contains even now a certain proportion of sesame oil which can be detected by a simple colour test in the laboratory. Sesame oil is added to check the use of vanaspati as an adulterant, but even this has probably not much reduced the extent of ghee being mixed with vanaspati. Efforts to find a suitable colour, either apparent or latent, have been made in various laboratories in the country for the last 20 years without practical success. The problem is probably a social one, rather than that of locking a policeman in every tin of vanaspati. Moreover a coloured cooking product would hardly be acceptable to the housewife. A product with a latent chemical which could be revealed by a simple test carried out by the housewife is also probably unlikely to be used in practice.

DR. REBELLO: What with present-day shortages and almost any edible oil going into the vanaspati, is there a colourless vanaspati available today? Perhaps what you really mean is that should more colour be added to it. If the addition of colour is going to really help distinguish vanaspati from ghee, it is worth considering. Food colours are of the synthetic type, and unless one uses only β-carotene, which is of plant origin, let us leave colouring alone.

There is much undue emphasis on the use of ghee in our country. How do vanaspati and ghee compare nutritionally?

DR. ACHAYA: The virtues of ghee have been much exaggerated, perhaps because of its attractive flavour and its association with the cow. Nutritionally, however, there is little to choose between various fats, and, if anything, ghee is today contra-indicated. Apart from the high price of ghee, it is nutritionally far more desirable and sensible to buy twice or three times the quantity of a good liquid cooking vegetable oil with a high PUFA (polyunsaturated fatty acids) content. Similarly, regional preferences for oils based mainly on flavour a e fortunately beginning to give way to nutritional considerations.

Is it necessary to add polyunsaturated fatty acids to vanaspati? The industry thinks that the addition of PUFA in the form of liquid oil has tended to raise the cost of vanaspati without any lasting benefits.

DR. REBELLO: The reason for this addition is to provide the essential fatty acid, linoleic acid, which is not synthesised by the body. This fatty acid is converted into those powerful substances responsible for the well-being of the human body — prostaglandins. And prostaglandins have a host of useful functions in the body; they are necessary to maintain body weight and skin texture, for proper kidney and liver function, blood circulation, reproduction, lactation, etc. Prostaglandin synthesis is a continuous process occurring in the body and what is little known is that these substances are destroyed when the blood passes through the lungs. Therefore, these have to be continuously replenished in the blood stream and the only source is linoleic acid. To cut it out from vanaspati which is poor in linoleic acid would be to stop the continued flow of prostaglandins in the blood.

DR. ACHAYA: While many Indian families use liquid vegetable oils as well as vanaspati in their kitchens, there must be a fair number, especially of affluent families, who use only vanaspati. A higher level of PUFA in vanaspati can certainly do good and, cannot, in any case, do any harm. It is difficult to see how the cost goes up when the price of an oil is less than the price of hydrogenated oils because of the extra cost of hydrogenation.

In this context, even the desirability of the present straight hydrogenation of liquid oils to hard products low in PUFA seems to need serious scrutiny. The rigid control of the hydrogenated product now has become a straight-jacket which is strangling the possibilities of developing hydrogenation techniques to make products nutritionally better than vanaspati.

It is said that NCST's (National Committee on Science and Technology) proposed development projects on oils and fats are rather irrelevant. What are your comments?

DR. ACHAYA: In the face of desperate shortages of oil, pursuit of technology directed to using oil must suffer the criticism of being irrelevant. Yet process development in new areas and new ways needs to go on. The fact that a certain hydrogenation system is in wide use in the country does not mean that other kinds of hydrogenation or other aspects of the hydrogenation process need not be examined. Hydrogenation by faster methods, special types of hydrogenation to make specific products, and the blending of the hydrogenation process with other processing methods, are all examples of techniques which require study. For example, hydrogenation coupled with other types of processing is used in the West to give margarines high in PUFA which spread better than butter when kept in a refrigerator.

What are the long-term effects of the use of liquid oils and vanaspati on the human body?

Research on animals and human volunteers has indicated that the ingestion of vanaspati tends to raise the serum cholesterol levels. Raised serum cholesterol is known to be one of the factors which increase the proneness to atherosclerosis and other cardio-vascular diseases. The melting point of vanaspati should be kept below 37°C for optimal absorption. Long-term studies on the ingestion of vanaspati have been carried out largely on animals and these do not appear to show any harmful effects except the raise in blood cholesterol levels.

Toxic effects arise mostly out of contamination, for instance, argemone in mustard oil. In fact, argemone contamination is now known to occur in almost all edible oils. The other is aflatoxin contamination from groundnuts. Fortunately, aflatoxin contamination in oils is minimal since only traces of the toxin gets into the oil, and even these traces are removed during refining. Recent research indicates that a 20 per cent mustard oil content in the diet results in fibrosis of the heart muscles in experimental animals. This is due to a high content of erucic acid in mustard oil. Rapeseed oil also contains this long-chain fatty acid. It is not possible at this stage to say what would be the long-term effects of the use of mustard oil, but there need not be any undue alarm since the average oil intake in this country is as low as 13–14 gm per day per adult — much below the 20 per cent used in the experiments. It is also possible to grow mustard or rapeseed strains practically free of erucic acid.

C. Gopalan

[Dr. Gopalan is Director of the National Institute of Nutrition, Hyderabad.]

HOW TO TREAT INDUSTRIAL WASTES

G. K. SETH

LAKE Eyrie in the US is dead. Wastes from the thick cluster of factories on its shores choked it to death. The Rhine is no more a sparkling river. They now call it Europe's largest sewer, full with wastes from the industries mushrooming on its fertile banks. Whose turn will it be next?

Whether one wants it or not, pollution is a byproduct of rapid, unplanned industrial progress. Unless controlled early, it can do enormous damage. The smoke and the chemical fumes that the factories spit out can contaminate the air you breathe, and affect your health. The liquid wastes can kill life in the rivers and make the water unsuitable for drinking.

In India, we have another peculiar phenomenon which worsens this problem. Rainfall, which can dilute and wash the wastes away in rivers, occurs only for about three months. For the rest of the year, the rain-fed rivers trickle thin, degraded with wastes. And downstream the industrial areas, the water becomes useless for drinking and, often, a disease-carrier. For, the liquid wastes contain organic matter, chemicals like acids and alkalies and at times toxic materials.

This situation, of course, can be avoided — if we clean and treat the effluents before pumping it out into the rivers or disposing it on land. But who should do this? The industries argue that the cost is prohibitive; it will push up the cost of manufacture. Actually this need not be so. Depending on the quality and quantity of wastes, there is for every situation an ideal solution which is most economical. For example, the oxidation pond is ideal for situations where land is available. The aerated lagoon and oxidation ditch are suitable where land is limited and costly.

The aim of this article is, therefore, to highlight some of the low-cost treatment methods that have been developed. Some of these methods are being used in the country. Several such low-cost waste treatment processes have become popular in other countries during the last ten years. In India, however, excepting stabilisation ponds (oxidation ponds), no other method has become popular. And in most of the cases, conventional processes like activated sludge and bio-filtration are still being used.

The Central Public Health Engineering Research Institute in Nagpur (CPHERI) has evolved a number of alternative low-cost waste treatment methods for many industries like dairies, tanneries, fertiliser factories and paper mills. We shall discuss some of them.

FROM THE SHEER volume of waste they discharge, dairies pose a major problem. They let out two to three times more waste water than the milk they process. The wastes contain much organic matter from spills, leaks and washings. If discharged untreated into a fresh water stream, these wastes consume the oxygen dissolved in the water (this oxygen is necessary to sustain plant and fish life in water) and kill life in it. In this respect, dairy wastes are twice as bad as sewage. The wastes also ferment readily, releasing foul odour. This waste water is used for irrigation, but unless well diluted, they may damage crops.

Modern dairies are coming up in a number of cities. So economic methods of treatment too become important. Dairy wastes are alkaline (pH 7·8–10) and contain suspended solids. They can be treated by almost any of the methods used for sewage treatment. But the most economic would be anaerobic lagoon followed by oxidation pond or aerated lagoon and oxidation ditch. If sufficient land is available, the wastes may be diluted and let out on land. The extent of dilution and the rate of disposal, however, depend on the nature of the soil; sandy loams are the most suitable. With underdrainage, clayey soils can also be used. In any case, wastes disposed on land need less treatment than those flowing into inland streams. Much of the treatment can also be

Behind the jargons . . .

Biochemical oxygen demand (BOD): The amount of oxygen consumed in the biochemical oxidation of organic matter in water.

Chemical oxygen demand (COD): A measure of the oxygen-consuming capacity of inorganic and organic matter present in water or waste water. It is expressed as the amount of oxygen consumed from a chemical oxidant in a specific test.

Oxidation ponds: Oxidation ponds are shallow basins excavated in the ground for purifying settled sewage or other waste water by storage under climatic conditions like warmth and sunshine which favour the growth of algae. Bacterial decomposition of the waste matters releases carbon dioxide and heavy growth of algae develops. Ammonia and other substances needed for plant growth are used up, and dissolved oxygen is kept at a high level. The driving force in this type of self-purification is photosynthesis.

Aerated lagoons: Aerated lagoons are ponds 2·5 to 4 metres deep with a geometric configuration. They are supplied with air all through by diffused aeration or surface aerators. This process does not involve sludge recycling or primary treatment or sludge digestion in separate digesters and the waste can be purified within relatively short periods —2 to 3 days compared to 7 to 10 days in natural stabilisation ponds. The system maintains the dissolved oxygen all through the lagoon. This keeps it free from odour and flies. Compared to a stabilisation pond, the system needs less land.

Anaerobic lagoon: Anaerobic lagoon may be described as one in which raw sewage (or strong settled sewage) is retained for a short period in contact with deposited digesting solids. Although dissolved oxygen is normally zero in the entire content of the lagoon, BOD reductions are more than that expected from the removal of solids.

Activated sludge process: This is a biological waste water treatment process in which a mixture of waste water and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated waste water (mixed liquor) by sedimentation and wasted or returned to the process as needed.

Bio filtration: Here the liquid is passed through the medium of a biological filter, thus permitting contact with the attached zoogloeal film that adsorb and absorb fine suspended, colloidal and dissolved solids and release the end products of biochemical action.

eliminated by recovering dairy byproducts like butter and cheese from good milk and ghee and casein from soured milk.

THOUGH accurate statistics are not available, there are about 193,000 tanneries in the country, producing about 87 million pieces a year. Mostly these are small-scale units. Tannery waste water ranges from 3,000 to 3,500 litres per 100 kg of hides and skins processed.

What are the pollutants in tannery wastes? The worst are liming and vegetable tanning liquors. Other objectionable constituents are the colour, high suspended solids (560–1,900 mg per litre), BOD, COD, chlorides (2,000–5,000 mg/litre) and chromium (from chrome tanneries only) — all exceeding the permissible limits. From the point of view of treatment cost, however, it is sodium chloride or common salt that poses the greatest problem. Such high salt contents (from skin dustings) have turned both surface and ground waters saline in some areas in Tamil Nadu. Dissolved solids and chloride contents have been traced in ground water 10 km away from the point of discharge.

All the sewage treatment processes can well be used for tannery wastes too. Screening (for coarser impurities and hair) and settling for at least four hours in settling tanks form the

TABLE I. CAPITAL COSTS AND ANNUAL EXPENDITURES FOR TANNERY WASTE TREATMENT METHODS

Cost per kg of hides and skins processed per day (in Rs)	Capital cost plus capitalised running cost per kg of hides or skins (in Rs)	Total annual expenditure to defray all running costs including repayment of loan (in Rs)
10 to 16	10 to 40	1·20 to 3·40
15 to 24	20 to 52	1·70 to 4·50
20 to 32	30 to 63	2·10 to 5·50
25 to 40	48 to 84	4·50 to 7·25
26 to 43	53 to 91	4·15 to 8·00

TABLE II. CAPITAL AND RUNNING COSTS FOR FERTILISER WASTES

Using lime* for pH increase	Arsenic, fluoride, phosphate, oil & grease removal	Treatment and disposal of ammonia and urea plant effluents			
		Air stripping	Simple lagooning	Nitrification	Storage for 9 months and disposal in monsoon
Capital cost (Rs in thousands)	200	4,400	2,100	3,013	6,500
Running cost † (Rs in thousands)	68	2,300	2,076	460	150

* If caustic soda is used instead of lime the capital cost and running cost per annum will be Rs 3,300,000 and Rs 4,300,000 respectively for air stripping.

† Running costs include cost of power and chemicals.

essential primary treatment. The settled waste can be further treated in aerated lagoons, anaerobic lagoons, oxidation ponds, oxidation ditches and trickling filters.

But if the salt content is so high that it pollutes ground water, it may need some special measures. Dusting of the salt-preserved hides will minimise the salt content from soaking operations. By soaking the dusted hides in a small volume of water before regular soaking, the quantity of salt-bearing waste itself can be reduced. The high salt content wastes like soap and pickling liquors may be separated and evaporated in solar evaporator ponds. The rest of the waste may be mixed and treated as explained earlier.

THE FERTILISER industry has grown rapidly in recent years. There are about 18 plants working; six more are to be commissioned soon. And though most of the units have been producing nitrogenous fertilisers, several new plants now produce phosphatic fertilisers.

Both plants, however, discharge highly polluting and toxic wastes. Nitrogenous effluents primarily kill fish and affect public water supplies. The addition of phosphatic wastes has now accentuated the problem of eutrophication in reservoirs, rendering the water unsuitable for several purposes. These wastes, if thrown on land, can damage the soil and crops.

Only water-polluting wastes are considered here. Fertiliser effluent has these average characteristics : it is alkaline (pH 7·5–10·2) and contains 5,100 mg solid particles per litre. Other pollutants include ammonia-nitrogen (730 mg/litre), urea-nitrogen (615 mg/litre), phosphorous tetroxide (15 mg/litre), fluorine (15 mg/litre) and arsenic (1·5 mg/litre).

Segregation of certain effluents is common in any industrial waste treatment. For fertiliser

TABLE III. COST ESTIMATES FOR PULP AND PAPER MILLS PRODUCING 50 TO 500 TONS PAPER PER DAY

	Aerated lagoon Rs	Anaerobic-aerated lagoons	anaerobic-aerated lagoons	treatment for 200 tons per day plant
Capital cost/ton of paper	14,000-17,000	15,800-18,400	13,400-16,700	17,000
Running cost/annum/ton	1,960-2,450	1,670-2,340	800-1,460	—
Land for 200-ton capacity (acres)	20	35	45	8
Cost of nutrients/annum/ton of paper	2,300	1,600	1,600	2,300

wastes, this is both feasible and economical. Several processes to remove ammonia have been studied both in the laboratory and the field. The choice, however, depends on several factors, including local conditions. The methods considered include: (*i*) steam-stripping which is economical at or above 3–4 per cent ammonia concentration and if surplus steam is available; (*ii*) air-stripping towers at pH 11, (*iii*) simple lagooning at pH 11; (*iv*) nitrification; and (*v*) direct disposal after *minimum treatment* and adequate storage.

PULP AND PAPER industry is one of the largest water consumers, and, therefore, one of the largest waste producers too. Currently there are 57 mills making 770,000 tons of paper a year. This is estimated to rise to 1,000,000 tons within the next two years. While the water requirement for a ton of paper is around 80,000 gallons, the effluent discharge is around 60,000 gallons, with objectionable constituents like colour, high suspended solids (375–2,490 mg/litre), BOD (160–1,370 mg/litre) and COD (470–2,940 mg/litre)

The BOD and suspended solids are beyond the tolerable limits for discharge into inland surface waters. In some cases, the dissolved solids and the sodium content violate the irrigation standards too. Most of the mills pump the effluents into streams after very little treatment. A few store them in holding ponds in the dry season and let it out into rivers when the rivers are full.

All the sewage treatment processes can be successfully used for the treatment of pulp and paper mill effluents. Cost estimates based on pilot plant studies using anaerobic-aerobic lagoons are given in Table III.

But there is one problem. Even after such treatment, the colour still remains; none of the biological methods can remove this. Massive lime treatment and activated carbon treatment are known to do the job well, but the economics under Indian conditions are yet to be worked out. Soil too can be used as a medium for removing the colour. In fact, disposal on land after pretreatment seems to be the best method. But large pieces of land will be needed in most cases.

Dr. G. K. Seth is a scientist with the Central Public Health Engineering Research Institute, Nagpur.

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in lighter moments.

WHEN a 41-year-old widower decides to marry again, what should he look for in his new bride? Johannes Kepler, the well-known astronomer, approached the problem scientifically. He started with discussions with his friends about all sorts of qualifications the bride ought to possess. Should she be a widow, a spinster or just a young girl? Should she be poor or a rich man's daughter? Tall or short, stout or thin? So on and on, the dicussions went.

But successful marriages don't obey clear-cut laws. Kepler had to choose from 16 candidates, and the man who could count the stars on his fingertips was floored. Women, he discovered, are not heavenly bodies with fixed weight, mass and orbit; rather, they are complex entities, each a permutation and combination of several character traits. Kepler managed to work through the data of four women and then broke down. He picked up the fifth name and said he would marry her.

History says he didn't regret it.

* * *

DURING the gory days of the French Revolution when the guillotines were never allowed to dry, many a well-known scientist and philosopher lost his head — literally — for associating with the aristocracy. But the tempest had not knocked on the doors of the French astronomer M. Lalande. He remained so absorbed in his study of the stars that he never came out of his house and was missed by the revolutionaries.

After the fury subsided, a friend asked him how he had managed to escape the fate of his fellow scientists. Lalande smiled and replied: "I must thank my stars!"

* * *

TALKING of astronomers, there was one known as the most accurate observer of the night sky—Tycho Brahe. He was also a patient man, calm and cool in his work with the stars. But in matters more mundane, good old Tycho could blow up to the point of violence. While his eyes knew the peace of the stars, his nose bore the mark of earthly foibles.

It happened like this: Tycho had a quarrel with a young noble at a party. And when you quarrel with a noble, you ought to have a duel. The duel was fought in pitch darkness, and before he could even see its glint, his opponent's sword had taken out a part of Tycho's nose. For the rest of his life Tycho had to cover the scar with a thin plate of gold and silver alloy.

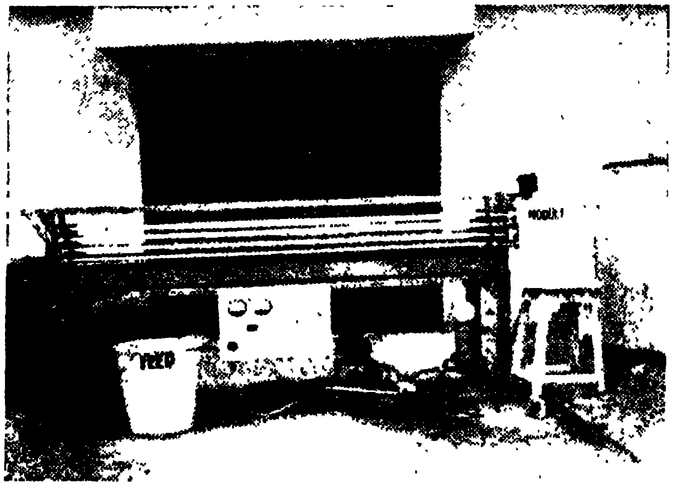
S. N. Munshi

Sea Water Needn't be Salt

"WATER, water everywhere, nor any drop to drink." This may well be the predicament of our descendants, thanks to the population explosion and rapid industrialisation.

Though some four-fifths of the earth's surface is covered with water, most of it is undrinkable because it is saline. And the demand for water, both for domestic and industrial purposes, is increasing day by day.

What is the solution? Desalination of brackish (salt-containing) water is the only answer, according to scientists. The salts and other impurities must be taken out of saline water to make it potable.



A prototype model of the tubular type reverse osmosis plant

Of the many techniques of desalination the one that is very much in the air today is called "reverse osmosis," in which saline water is subjected to a certain pressure so that pure water flows spontaneously through a semi-permeable membrane, leaving the salts and other impurities behind. The semi-permeable membrane is the heart of this technique, but the technology of its preparation has been a closely guarded secret in the advanced countries.

Scientists of the Central Salt and Marine Chemicals Research Institute, Bhavnagar, have now developed a tubular type semi-permeable membrane suitable for application in a reverse osmosis plant of their own design. Both the techniques of membrane preparation and plant fabrication have been patented. (See also "Technology News", SCIENCE TODAY, June 1972, p. 54).

The tubular type reverse osmosis plant is the invention of Mr. A. S. Kane, Dr. M. V. Chandorikar and Dr. D. J. Mehta. Its tubular membranes are prepared by extrusion-casting from a solution comprising cellulose acetate, formamide and acetone. The cast membranes, after evaporation of the solvent, are subjected to cold water immersion and hot water 'annealing treatments. The tubes are then adequately supported by wrapping nylon or polyester fibre cloth and inserting them into perforated tubes, whose ends are sealed by means of specially designed rubber and metallic fittings. This allows them to withstand expansive stresses due to hydraulic pressure and prevents intermixing of the product water and the concentrate left behind..

In the reverse osmosis plant, the tubular membrane elements are fitted leak-tight to "headers" which distribute the feed solution in a desirable pattern. The number of tubes and headers constituting a plant depends on the desired capacity.

The brackish water is pumped under high pressure, a back-pressure regulator valve maintaining the required pressure. The flow is maintained in the turbulent region, so that the pressure in excess of the osmotic pressure of water forces pure water to ooze out through the membranes. And as the reverse osmosis proceeds, the concentration of impurities in the flow within the tubes increases, finally reaching a level when the effluent is rejected out of the system through the back-pressure regulator.

The cost of desalination by this process depends on the capacity of the plant. A Bombay firm, which has purchased the know-how, is reported to have developed a 40,000 litres/day capacity prototype that would deliver drinking water at about 50 paise/1,000 litres. By other desalination techniques (e g, ion-exchange) the cost may be as high as Rs 2·50/1,000 litres. The know-how has been released to three other firms by the National Research and Development Corporation of India.

The tubular type reverse osmosis plant has

(Continued on page 55)

TRACKING DOWN THE ABORTIONIST

SCIENCE AGAINST CRIME—XI

Artificial abortion is fraught with danger and since it is much sought after, the professional abortionist has a flourishing trade. Often the operation ends in death and the pathologist may have to indicate the mode of abortion, which often gives a clue to where and by whom it was performed

J. B. MUKHERJEE

A PREGNANT girl died, evidently after an abortion had been performed on her. Pathological examination revealed the bacillus *Cl. Welchii,* probably introduced by the insertion of slippery elm bark, one of the materials used by abortionists, into the uterus. Police raided a professional abortionist's house, and recovered similar pieces of slippery elm bark, which on examination revealed *Cl. Welchii,* thus linking him with the offence.

Even if the girl had not died, the abortionist would have been culpable under the law, for inducing a criminal abortion (see box on page 53).

An abortion or a miscarriage is a termination of the pregnancy at any stage during the nine months of uterine life. It has been estimated that one in every five pregnancies abort either naturally or by artificial means. Artificial abortion is usually resorted to by an unmarried or widowed mother to save face; often, it is the educated middle class women who go in for abortion to prevent an unwanted addition to the family.

In India about 6½ million abortions take place every year, nearly 4 million of these being illegally induced. In the USA 1 to 2 million illegal abortions are done each year. Even in Japan, with a permissive abortion policy, the registered abortions are about one million a year; the unregistered ones may be higher. The highest number of induced abortions is in the Soviet Union — 2 to 6 million a year.

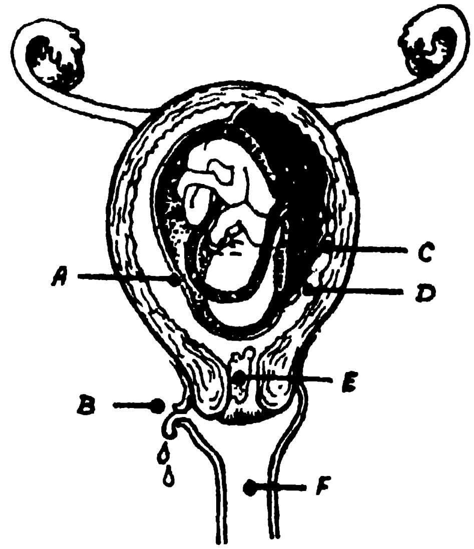
Only a few cases of abortion punished under the law have been reported in India. This is because abortion is done in secrecy, owing to the social stigma attached to it; the offence is non-cognisable and cases of criminal abortion come to the notice of the police only when the woman dies or when someone reports the case to the police. Often, the woman though unmarried or a widow, claims to be married and gets herself admitted to a hospital with a history of bleeding of her vagina from a minor accident or fall; later examination reveals local interference, but this along with the criminality behind it cannot be imputed obviously at the time of admission. Even when death occurs following sepsis (infection), the police are ordinarily not informed, hence autopsy examination is usually not sought for. Even when medico-legal examination reveals an act of criminal abortion, it is difficult to prove the charge because the evidence, circumstantial and direct, may not be sufficient to connect the crime with the criminal, and the benefit of the doubt goes to the mother.

During the last seven years, of the 7,600 cases examined at the Calcutta Police Morgue, only five cases were alleged to be criminal abortions. In one case, cremation was withheld by the local youths on suspicion; post-mortem examination of the unmarried mother revealed that criminal interference with pregnancy had caused her death. In another case, one quack doctor fled from the scene on seeing his patient die during criminally induced labour; the body was recovered from his chamber later. Autopsy examination confirmed the suspicion.

Methods adopted

THE METHODS adopted to procure criminal abortion usually depend upon the stage of pregnancy and the means available. The techniques of self-induced and illegal abortion are far more bizarre than those used in hospitals and clinics. At the end of the first month, after missing the menstrual period, the woman feels nervous and guilty. She goes in for violent exercises, hot baths and strong purgatives in an attempt to rid the uterus of its embarrassing contents. At the end of the second month, after again missing her period, she becomes panicky and tries abortion-inducing drugs, pills, hormones, vaginal douchings and drugs used in midwifery. Village quacks still use castor oil, followed by quinine hydrochloride, repeated two or three times, with or without ergot mixture. Other plants and fruits which have an undeserved reputation with the lay public as abortifacients but act chiefly as irritants are: seeds and unripe fruit of papaya, unripe pineapple, seeds of gajar (*Daucus carota*), bark of *lal-chitra* (*Plumbago rosea*), horse-radish, *mainphal* (*Randia dumentorum*), *gagharbel* (*Cuscuta reflexa*), *karit* (*Cucumis trigonus*), *sowa* (*Anethum graveolens*), *karela* (*Momordica charantia*), *lavang* (*Caryophyllus aromaticus*,) *jaiphal* (*Myristica fragrans*), *shajna saragwa* (*Moringa pterygosperma*), *zafran kesar* (*Crocus sativas*), *methi* (*Trigonella foenum-graecum*), juice of *madar* (*Calotropis gigantea*), juice of bamboo-leaves and *Euphorbia* plants. Also used in rural areas are abortion sticks on the tapering ends of which are applied pastes made from seeds of yellow oleander or *kaner* (*Cerbera thevetia*), *rati* or jequirity or Indian liquorice (*Abrus precatorius*), white oleander (*Nerium odorum*), marking nut (*Semicarpus anacardium*), bitter apple (*Colocynth*), asafoetida (*hing*), cantharides (Spanish Fly), copper sulphate or mercury salts. But these substances often cause complications and even endanger life, because the quantity of a substance that is needed to cause abortion will almost certainly kill the mother. There is no substance that acts on the uterus alone.

Injection of fluids to produce abortion may be indicated by membranes being pushed in by the fluid (A), by presence of the fluid in various portions of the womb and vagina (B, C, F). The placental membranes may be separated (D) and the mucus plug dislodged (E)



After the third or fourth month, the woman becomes dead certain of her physical condition. Other measures having failed, she desperately resorts to mechanical methods, either by herself or with the aid of a professional abortionist. The woman in her ignorance of her own anatomy, may force a pencil, knitting-needle or hair-pin into the uterus and rupture the membranes (placenta), thus inducing abortion. In villages, the *dais* act as semi-skilled accoucheurs who insert sticks smeared with abortifacients into the uterus causing rupture or dilatation, with bleeding. The object of these exercises is to induce contractions of the womb and thus expel the foetus by detaching it from its attachment to the wall of the womb. (But the contents of the womb are surprisingly tenacious, and even when the mother has died, the embryo is often intact). The foreign bodies inserted are then taken out and the woman is asked to report to any maternity hospital as a case of " incomplete or threatened abortion "; there the evacuation is completed by the surgeon. Such patients are generally silent about the nature of the instrument used.

A semi-skilled abortionist may also use a laminaria tent, a uterine sound, a soft rubber catheter or gum elastic catheter to rupture the uterine membrane to initiate labour. A skilled professional abortionist will prefer to do dilatation and curretage (removing the uterine contents) under general anaesthesia in a clinic or a nursing home, after preliminary dilatation is done. When the pregnancy is advanced, hysterectomy (opening the uterus and removing its contents by cutting open the abdomen) is preferred. A recent method of inducing abortion is to replace some of the amniotic fluid (the fluid in which the embryo is bathed) with hypertonic glucose or saline solution. In Western countries, a Higginson syringe is used to force fluid containing soap or an antiseptic solution through the cervix into the uterus. Vacuum suction aspiration is also attempted.

A novel but dangerous method, also used unsuccessfully in the West, is to introduce tablets of potassium permanganate into the vagina or cervix; the resultant erosion may cause gangrene and thrombosis. Cases have also been reported of the use of electricity; the negative pole is applied to the cervix in the hind vaginal arch and the positive pole is placed over the sacrum or lumbar vertebrae; an electric current of 100 volts is passed, resulting in violent contraction of the uterus and expulsion of the foetus.

PRACTICALLY ALL methods are fraught with danger. Use of abortifacients may cause systemic poisoning. Mechanical interference involves the dangers of infection and sepsis, apart from injury to the private parts. The use of syringes commonly causes "embolism": when soapy water is used, the intake nozzle may slip out of the fluid into the froth of the fluid, or the valve may be leaky, thus forcing air bubbles under pressure into the womb. These air bubbles can then find their way into the blood vessels of the pelvis and thence to the heart and brain, causing rapid death. The bleeding and shock, if not fatal, may pass off after half an hour. Sudden death may also occur from reflex cardiac arrest (see "Death by Drowning", SCIENCE TODAY, July '72, p. 39), which can be caused merely by touching the neck of the womb with the instrument, especially in a nervous woman.

Chronic infection often follows from criminal induction of labour, wrecking the life of the patient. Unskilled and semi-skilled abortionists have scant regard for hygiene, doing their work in secrecy. Still, very few die from criminal abortion. Dr. D. Lahiry and Dr. (Mrs.) M. Konar in a ten-year survey of abortion mortality at the Eden Hospital Medical College, Calcutta, found that 9·5 per cent of all obstetric admissions consisted of abortions. Death from abortion was one per cent. Most of the deaths were in the 21–30 age group; this group, with five children, had a greater tendency to procure abortion. In the case of deaths of women in their first pregnancy, three out of four were unmarried. Pregnancy was mostly terminated between the 8th and 16th week.

A private medical practitioner who comes across a case of self-induced abortion does not have to intimate the authorities, especially in view of the doctor-patient relationship. But when interference has been done by another person and damage to tissues is so severe that it may result in death, then it is quite a different matter. By withholding information at an earlier stage, evidence valuable in apprehending the culprit may be lost. Hence, while examining such a patient he has to warn her that he might have to inform the police.

ABORTION AND THE LAW

CAUSING an abortion, or even an attempt to do so, whether the mother is pregnant or not, by anyone including the mother herself is punishable under law, except when the abortion is therapeutic or when done as provided under the Medical Termination of Pregnancy Act (1971). Secs. 312-316 IPC prescribe imprisonment of either kind ranging from three years to transportation for life. But the offence by itself is non-cognisable and hence beyond the direct purview of the police by itself.

Abortion or **bhruna-hatya** was punishable even during the time of Kautilya. In ancient Rome abortion was an accepted practice. Christianity frowned upon it until the 19th century; even now the Catholic Church forbids it on religious and moral grounds. Hindu women have always been taught to consider abortion a heinous sin. Muslim law has never given sanction to illegal abortion. The Buddhist attitude has been one of acceptance, on the ground that bringing an unwanted child into the world is the worse alternative.

The present thinking is that the woman should decide whether she wants to be a mother; if she decides otherwise, let termination of pregnancy be done within the letter of the law by an expert, under proper supervision. The need for revising the age-old law has been felt, and in 1971 the Medical Termination of Pregnancy Act was passed, which makes the termination of a pregnancy legal when a continuation of the pregnancy would injure the physical or mental health of the mother, or if the child when born would suffer from physical and mental defects, or when family planning methods have failed, or if the pregnancy is alleged by the pregnant woman to have been caused by rape. The operation is to be carried out in a Government hospital, and two medical practitioners are necessary if the pregnancy is of more than 12 weeks' duration.

With the increasing emphasis on family planning, and sexual permissiveness, the number of abortions is likely to increase. Abortion, when necessary, should be performed under hygienic conditions and supervision, and within the framework of the law. The establishment of hospitals in rural areas and cities for termination of pregnancy under the new law would prevent the exploitation of women by charlatans operating in secret under unhygienic conditions.

J. B. M.

NEXT MONTH: **PHOTOGRAPHY IN CRIME INVESTIGATION**

No Sooner Born Than Slain

Women sometimes kill their infants, under the stress of child-birth, or soon after, when the balance of the mind is often disturbed, especially if they are unmarried and have been unable to get an abortion done. In India, female children were regarded as a liability and, in some communities, used to be destroyed soon after birth, but with the spread of education this evil has almost disappeared.

The law is more lenient towards women who kill their own infants. The crime is considered as infanticide and is treated on a par with manslaughter provided the infant is recently born (" recent " for this purpose meaning having been born within 12 months of its death, and provided the destruction was done by the mother. Any other person (even the husband) assisting in the wilful destruction of the child can be charged with murder.

The law regarding infanticide is ticklish. Sometimes a woman is charged with infanticide even when her child is still-born. The prosecution is then required to prove that the infant was capable of being born alive, i e of existence independent of its mother. The Infant Life (Preservation) Act (1929) of the UK assumes that a child is capable of being born alive after a pregnancy of 25 weeks, i e a foetus becomes a legal entity after this period in the womb. A foetus of this age is 1000-1400 gm in weight, 34-36 cm long, with distinguishable nails, separated eyelids and well-formed eye-lashes; the skin is dusky reddish in colour.

In Indian law, the criterion is " live birth ", even if the child had not breathed or had been incompletely expelled from the vagina. The birth-cry is not always proof that the child was born alive. An immature or delicate child may not utter a cry, even if it be born alive. The most important indication that the child was born alive is the establishment of respiration. This is indicated by the shape of the chest, which is flat at first but becomes drum-shaped after full respiration. There are also changes in the lungs which are small and puckered initially, but after complete respiration increase enormously in volume, and are mottled in appearance. The stomach shows mucus and air bubbles if respiration has been established.

The police will also want to know how long the child survived after birth. The exact period is not easy to determine. The presence of milk in the stomach in a state of digestion is strong proof that the child was not only born alive but lived for some time. The skin of a new-born infant is bright red but changes colour in a few days' time. The cut end of the umbilical cord begins to shrivel within 12 to 24 hours.

The commonest mode of infanticide is suffocation by closing the mouth and nostrils with a towel or with the hand; or by pressure on the chest. In such cases, the nose, lips and angles of the mouth are likely to bear injuries. Strangulation with a rope or even with the umbilical cord is also practised. Drowning, by immersing the child's face into a cauldron of warm milk used to be a common practice around Varanasi. Fracture of the skull bones may arouse suspicions of infanticide, but cases have been known where the child's skull has been fractured by precipitate labour, especially in a woman with a roomy pelvis. The appearance of the cut ends of the umbilical cord often provides a clue; in cases of infanticide and concealed birth (also an offence) the mother often cuts the umbilical cord herself by tugging, in which cases the ends of the cord are frayed and ragged, unlike the neat cut produced by a knife or scissors. However, injuries round the infant's neck may be due to the efforts of a frenzied, lonely girl trying to deliver the child all by herself.

Where a charge of infanticide cannot be proved, the woman may be charged with the lesser offences of wilful neglect or concealment of birth.

Investigation

FROM THE NATURE of the injuries as well as foreign materials used, it is generally possible for a doctor, and of course the forensic pathologist, to infer the method used and whether the abortion was self-induced, or done by an unskilled or professional abortionist. Rough and shabby handling of the vagina, womb and cervix generally indicates unskilled use of instruments on herself by a primipara (woman pregnant for the first time) or by an unskilled abortionist. Recovery of foreign materials like portions of abortion sticks, pencil-ends, needles and twigs of abortifacient plants from the vagina or womb will indicate the article used for mechanical interference. There is also likely to be incomplete evacuation of the womb, unlike in the case of professional interference.

If a woman does not get the help of an abortionist she will try to interfere with the conception all by herself. Being ignorant of her own anatomy, and using, in haste and secrecy, instruments which may not be designed or suitable for the purpose, she is likely to injure her private parts. The implement might even be introduced into the bladder instead of the womb; and in endeavouring to dislodge the foetus, the instrument may rupture the vagina, the womb or the cervix. If the patient suddenly dies during the operation, the picture at the crime scene will be self-explanatory.

The presence of marks of volsellum forceps (a forceps with teeth) over the lips of the cervix, evidence of regular dilatation and curretage done to evacuate the womb, marks of incisions made on the abdomen for opening of the womb — all point to the work of a skilled and professional abortionist, more likely a medico, working in a clinic or a nursing home. Very little evidence will be left where the amniotic fluid has been replaced, or where vacuum aspiration (suction) has been used, except some marks of operative interference or remnants of the fluid used. Where electricity has been used to induce womb contractions, it is likely to leave local burn marks. It is important to determine how much the woman has done herself, unaided.

A visit to the place of occurrence will place things in their proper perspective. If implements are recovered there, there cannot be better corroborative evidence. Injuries and other marks on the body of the victim caused by these, together with the recovery of organisms which have caused infection from both the body and the implements, will be revealing. The use of a syringe is not at all common in India. When a syringe is recovered, its examination will reveal what fluid has been used and how recently the syringe was used; recovery of similar fluid from the womb and vagina of the woman aborted would be corroborative. The nozzle of the syringe may contain blood or tissue of the victim; if these contain similar organisms as those recovered from the blood or the womb of the victim, this will help connect the implement with the crime. If the victim has died of air embolism, the syringe is likely to have a leaking valve which will enable air to get into the syringe along with the fluid or even independently; the owner of the syringe and its connections when used as such will be criminally liable.

Material alleged to have been expelled from the womb may also provide evidence. Sometimes women who have been assaulted complain of miscarriage having occurred during the assault, to aggravate the offence. In one case, a woman alleged that owing to injuries inflicted on her abdomen during a quarrel, she had aborted and as evidence she brought a tissue alleged to be a foetus of three months' pregnancy; on microscopic examination, the piece of tissue was found to be a tumour.

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Ideas & Inventions *(Contd. from page 50)*

proved a boon to some Border Security Force units stationed in areas where fresh water is in short supply. The know-how developed by the CMRS scientists can also be used for recovery of important chemicals from industrial effluents.

An Artful Aid for Universal Grinders

WHEN the Radar Division of the Bharat Electronics Ltd., Bangalore, was faced with the problem of finishing certain components that were too small to be processed by ordinary means, an ingenious attachment contrived by one of the employees came to their rescue. The attachment that enables a universal grinding machine do the job of centreless grinding saved the company from going in for a centreless grinding machine worth Rs 1·5 lakhs. The inventor, Mr. Alfred Benjamin, is a skilled technician in the Radar Division's machine shop.

Mr. Benjamin's attachment virtually creates two machines out of one, without any significant increase in the capital cost of the original machine. Being used at the BEL on a 1,000 mm cylindrical grinding machine, it enables both cylindrical and centreless grinding jobs to be carried out on the same machine, thereby resulting in fuller utilisation of the machine's capacity by cutting down its idling periods.

The attachment essentially comprises a base with a control (regulating) wheel and a work-rest mounted on it. The work-rest has guides, the gap between which is adjustable to cater for varying diameters of the job. The drive for the control wheel, whose inclination can be varied from 0° to 15° according to the feed rate, is taken from the work-spindle of the grinding machine through a universal joint. The drive shaft is adequately supported by a set of four ball bearings, which are completely sealed.

Mr. Benjamin's attachment can handle all types of centreless grinding tasks, by any of the conventionally employed feed methods: through-feed, in-feed and end-feed. It can take jobs up to 20 mm diameter (steel) and is capable of finishing to an accuracy of ± 0·005 mm. The surface finish is as good as that obtained by any conventional centreless grinding machine.

Badiuddin Khan

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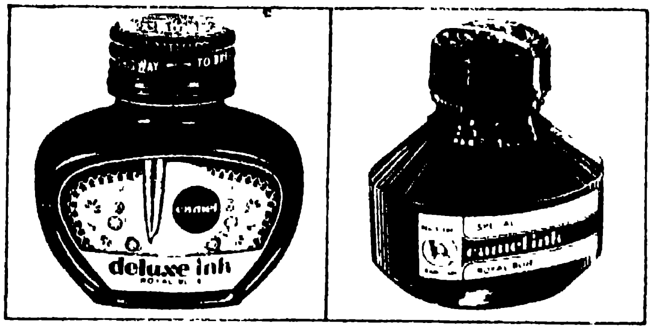

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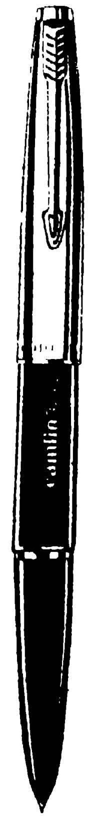

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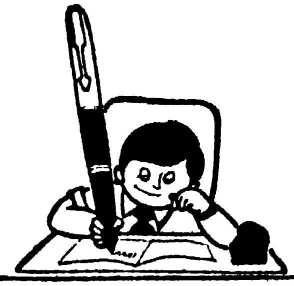


Vision 733

TRUE or FALSE?

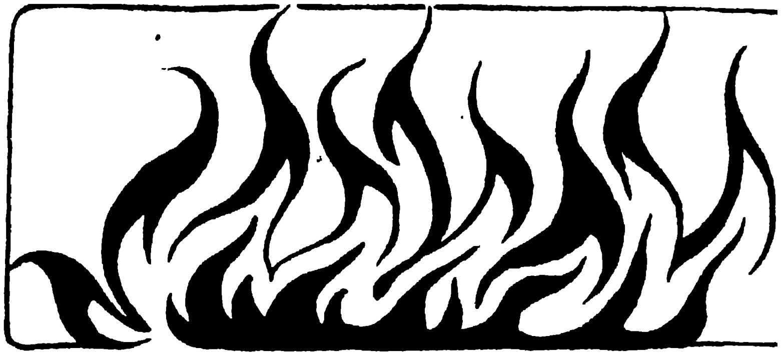
IN the middle ages, "Truth lived like a spy in an enemy territory. Today it lives like a guerrilla," said one myth-busting author. Does truth still live like a guerrilla in your mind, fighting superstitions and misconceptions? How many of the following popular beliefs are true?

1. The Arctic is a land of eternal snow and unendurable cold.
2. Lightning never strikes the same place twice.
3. Bulls are enraged by coloured rags.
4. Pigs are filthy gluttons.

Answers: None is true! Read on:

1. The myth about the Arctic stems from the assumption that the farther you go north of the Equator, the colder it gets. Actually the Arctic is dry and there is very little snow there. More snow falls in American Virginia than in the Arctic low-lands and New York City has lower mean annual temperature than Reykjavik, which is just below the Arctic Circle.
2. Lightning is *more* likely to strike the same place twice than not. Lightning strikes or passes through conductors whose total surface is only an infinitesimal part of the earth's surface. In the first ten years since it went up, the mast on top of New York's Empire State Building was struck 68 times.
3. " A red rag to a bull " has become part of the idiomatic language. Yet, the truth is, bulls are colour-blind. It is the motion of the matador's cape and not its colour that irritates the bull.
4. Pigs may wallow in ooze, but in nastiness, the sheep, that symbol of purity, surpasses it. As for gluttony, a pig will eat only as much as it wants to; the chicken, the horse and the cow know no limits.

(*More next month*)



WHAT DO YOU KNOW ABOUT YOUR COOKING GAS?

M. P. MUKHERJI

DID you know, your cooking gas which comes in a cylinder is really a liquid kept under very high pressure? If one cubic centimetre of this liquid is allowed to evaporate at room temperature, about 250 cc of gas will be formed. Now you can imagine how much gas is confined within that small cylinder. And the gas is very inflammable. No wonder careless handling invites troubles.

By law, each cylinder is tested before use and at fixed intervals subsequently. Also after each refilling, the cylinder is passed through water to test for leaks which show in the form of bubbles.

The fuel consists of a mixture of several gases obtained by cracking crude petroleum — the reason why it is also known as liquid petroleum gas or LPG. Butane butylene, propane and propylene form its major components. There are traces of other gases like ethane, too. In a hot country like ours, the butane fraction is greater — about 80 per cent. Propane has a lower boiling point, and it is used as a major component of LPG used in cold places. Except for minor changes in composition, the cylindered cooking gases marketed by various oil firms are virtually the same.

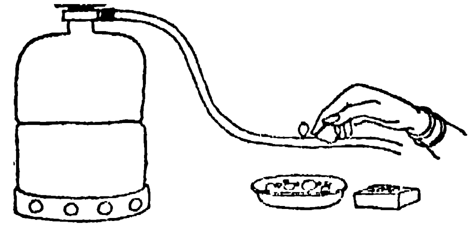
When the gas cock is turned, the liquid evaporates and rushes out under extremely high pressure. To control its flow, each cylinder has to have a regulator. Two types are available in this country (see diagrams on pp. 58, 59). Cylinders that are opened by a horizontal wheel on the top have a flat round regulator attached to the tube that connects it to the stove/hot plate. The valve is opened by turning the wheel anticlockwise. In this type, the valve must be closed securely before detaching the regulator while replacing cylinders. Such cylinders are protected by a metal cap during transport. In the second type, the regulator is fitted over the release valve. It is a recessed spring-loaded pin valve with a cylindrical regulator mounted on it. The top of the regulator is conical and has a button. To open the valve the button is flicked up. This is a safer type of valve; it closes automatically (even if in the open position) when the regulator is detached.

The domestic cooking gas is colourless and odourless. The repulsive smell? It is added deliberately to alert you in case of a leakage. You'll say, why on earth can't they make the warning smell pleasant? Because, then the purpose of adding the odour would be defeated. A pleasant smell would not jar your senses to make you rush to shut the valve when it's left open. Result: a sweet-smelling explosive mixture. Remember: in concentrations of just two to eight per cent, LPG forms an explosive mixture with air.

While replacing the cylinder...

. . . take extra care. Extinguish all sources of heat — kerosene stoves, electric hot plates, lighted oil lamps, coal/coke ovens, etc — before the delivery man detaches the regulator. If you have a wheel-type valve, it is advisable that you check the valve of the empty cylinder, and that of the new one too, before the security nut is opened. If the valve does not open easily, return the cylinder. Don't let the delivery man bang it with the spanner, or pry it open with a screwdriver. However, cylinders with the button valve do not require these precautions. Don't let the delivery man check for leaks with a lighted match.

One more precaution: when you light the gas stove, strike the match first before opening the gas cock. (This heavier than-air gas collects beneath the burner and can explode when ignited.) This way you'll prevent gas escaping into the room and save some too!

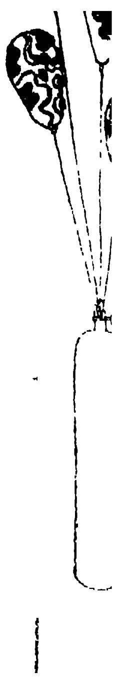


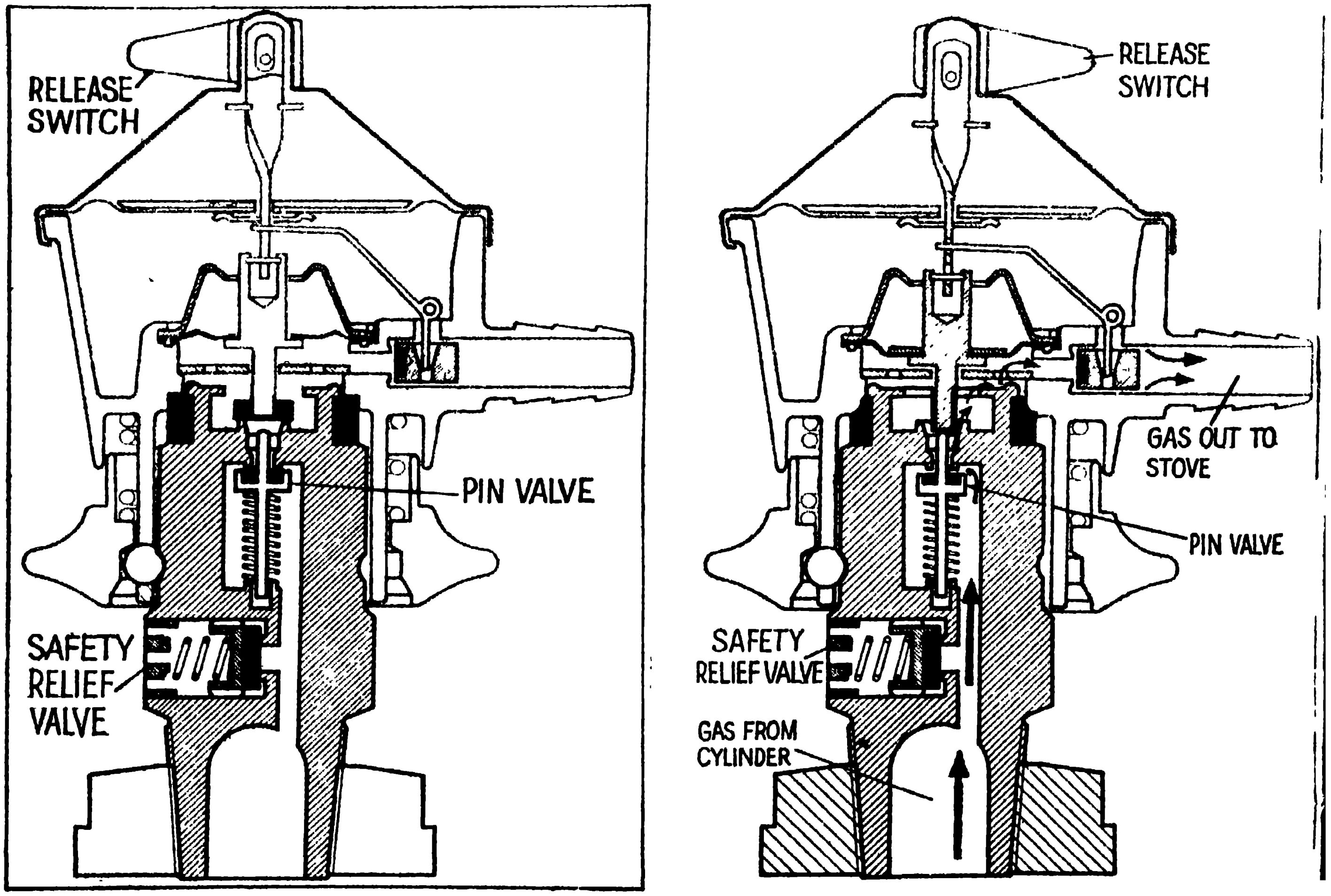
HOW DO YOU CHECK a leakage? Perhaps, you've seen the delivery boys using a lighted match stick. But this is not the safe way. In case the gas has already spread in the room, an explosion can occur. The safe way of looking for leakage is to dab the suspected spots with a fairly concentrated soap solution. If there is a leak, it will form a bubble. If your cylinder leaks in spite of closing the valve tight, remove it to an open space and notify the gas company. If, on coming home, you suspect a leakage of the gas cylinder, don't put on fans trying to facilitate ventilation. For that matter, *don't switch on any electrical appliance*. But if something is already on, don't rush to put it off either. When a switch is put ' on ' or ' off ', a spark is given out, and this is sufficient to ignite the gas. The switching-off gives a bigger spark.

Killer on the streets

Talking of explosive gas cylinders, did you know every fair ground has a killer at large? Of course, we are talking about the gas balloons that stretch high and taut from strings. They are filled from a cylinder on the spot. And this cylinder contains an extremely inflammable gas—hydrogen. One just cannot predict how or when the cylinder will explode. Several accidents are on record; one particular tragic incident took place on a Christmas eve near a church in a Bombay suburb. Returning home from the midnight mass, children flocked to buy the balloons. Someone inadvertently threw a lighted match-stick. It landed on the cylinder; the cylinder blew up killing three people and injuring six others. Among the killed was a 10-year-old boy. The balloon vendor and his assistant too were killed

Manufacture of hydrogen gas in a public place for filling balloons constitutes a rash and negligent act punishable under the Indian Penal Code.





BELOW: Pin valve regulators shown in closed (left) and open (right) positions. FACING PAGE: Wheel-type regulator valve

However tight and secure the gas cocks are, don't depend on them entirely. A leaky tube can cause problems. Always shut the cylinder valve, particularly before retiring for the night.

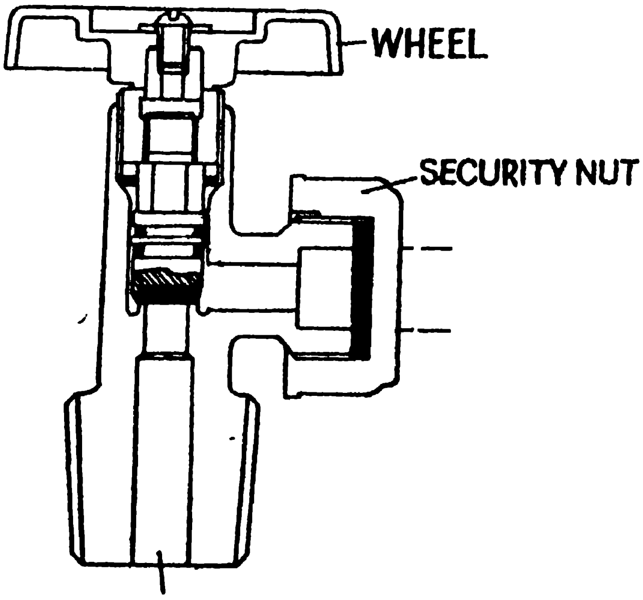
LPG is heavier than air, it flows down slopes and collects in pits and depressions. It can travel invisibly from the upper floors of a house to the lower ones and create havoc.

The liquid petroleum cooking gas is a boon to the housewife. No doubt she can forget the battles with the kerosene stoves or coal ovens, but the consequences of negligent handling can be deadly. From April 1972 to March 1973, 26 accidents involving LPG have been reported. The toll: 42 killed, 58 injured. Most of the victims were women, and most accidents occurred in the kitchen. And almost all could have been prevented.

How can you prevent the cylinder blowing its top? See that your kitchen is well-ventilated; even if there is a leakage, the gas will be dispersed. Inhaling the gas can be harmful too: oxygen starvation could result.

Always keep the cylinder upright, otherwise the liquid may seep out, evaporate and fill the room with gas. Keep it away from heat; the gas is kept under very high pressure and heating would cause it to expand and this could lead to an explosion. It is thus advisable to have all the stoves, hot plates, ovens, etc on a high platform, and the cylinder below it. Don't keep anything behind the stove; it can cause accidents. (See SCIENCE TODAY, May '73, p. 59.)

When the connecting tube is damaged, get a replacement from the gas dealers only. The tube is specially made from synthetic rubber which is resistant to chemical reactions from the gas and can withstand high pressure. Any other tube will not serve the purpose. Care should be taken so that the tube does not come off the connection when pulled inadvertently. Also, it should not have any sharp bends that can cause breakage. Constant exposure to oil and water can deteriorate the tube. Age is another damaging factor; change the tube every few years.



The Kerosene Stoves

Burn accident figures in any city or town reach staggering heights. In a single week last year, 26 people were killed by pressure stove fires in Bombay alone. Now why does this happen?

The answer lies with the kerosene stove, which many of us have to rely on because of the short supply of cooking gas. There are two types of kerosene stoves available in the market — the pressure stove and the wick stove.

The market is flooded with substandard goods. And the Indian Standards Institution mark is not mandatory. Many irresponsible manufacturers buy up discarded parts, polish them and sell them as new. It is not easy for a layman to pick out a good stove. Buying from a reputed manufacturer is one solution.

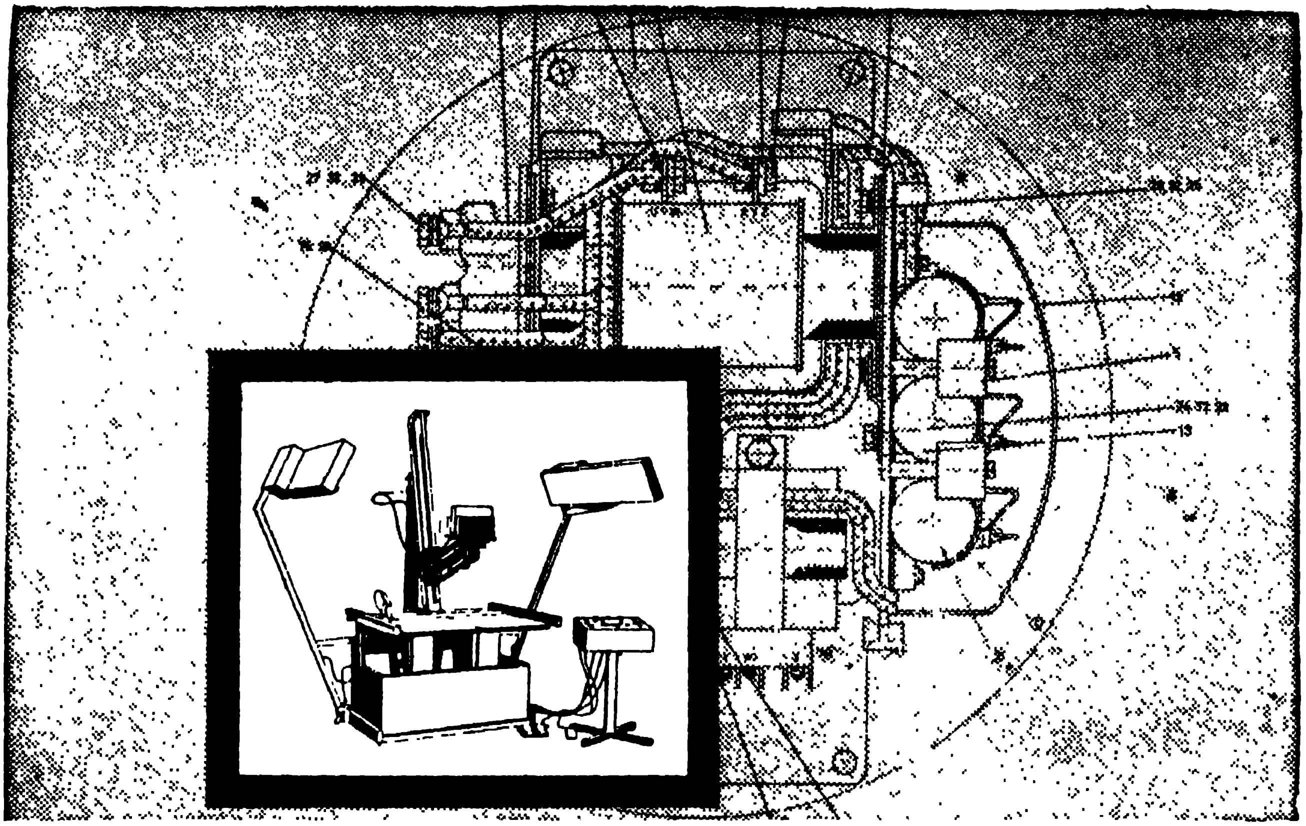
When you buy a pressure stove, examine closely for welded seams. For safe operation, the tank should be seamless. See that the burner and the tank are not soldered or cracked. Again, low-melting solders may be used. If the solder melts while heating and the fuel creeps out, put off the stove immediately. The nipple should have a straight, vertically bored hole.

The kerosene you use should be colourless and free from suspended particles. Filter it through cloth or cotton wool. When the pore is blocked or you haven't pumped sufficiently, the flame can strike back to the bulk kerosene in the tank. Overpumping too can lead to explosion. Another precaution: see that the pump screw and opening of the tank are secured well. The burner and nipple too should be checked.

Fill the stove up to two-thirds with kerosene — don't use any other fuel — and after igniting wait till the flame stabilises. If you cannot get a good flame, don't use the stove; persistent mild flames too spell danger. Don't operate the stove continuously for more than two hours. If you do, the temperature of the tank may cross the approved level, 60°C. Also don't fill the tank while the stove is burning. The greatest danger in pressure stoves is that of explosion. The metal bits fly like bullets injuring people in their path.

The wick stove is considered much safer, but its efficiency is about two-thirds that of a pressure stove. Remember a pressure stove has only three support legs. Keep it on absolutely level surface to avoid toppling. Change the rubber washers and clean the carbon deposits regularly.

Mr. Mukherji, who also wrote in our last issue about Diwali crackers, is Chief Controller of Explosives of the Government of India at Nagpur.



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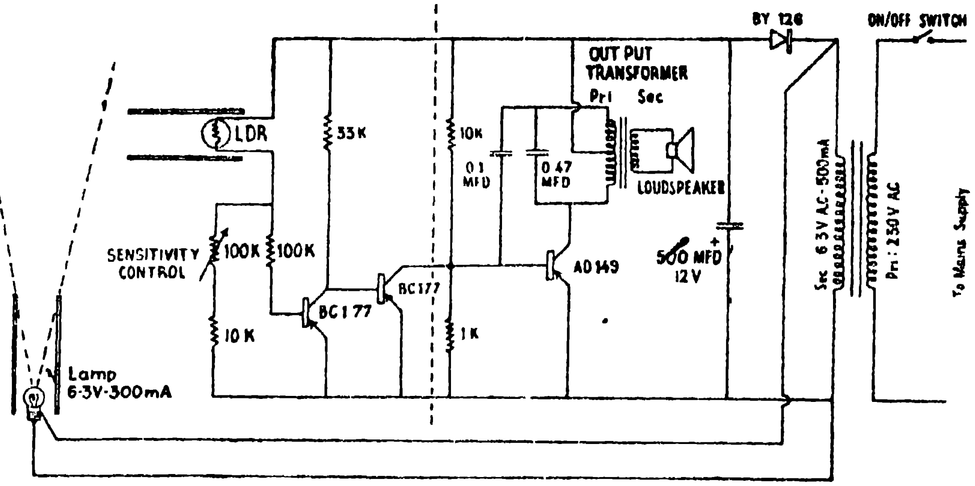


SMOKE DETECTOR

"NO smoke without a fire". Here's a device that detects smoke and thus gives you sufficient time to extinguish the fire.

This solid state smoke alarm detects photo-electrically the presence of smoke and sounds an alarm. This smoke alarm has to be installed very close to the ceiling, since smoke is generally lighter than air and thus first accumulates near the ceiling.

For easy understanding, the operation of the transistorised circuit can be divided into two parts. The part on the right hand side of the dotted line is an audio-oscillator. The operation of the audio-oscillator has been described in detail in various articles published earlier. The remaining part of the circuit consists of a two-stage directly coupled amplifier. The input to this amplifier is obtained from the voltage divider. The voltage divider consists of a light-dependent resistor (LDR), a potentiometer and a resistor. The potentiometer provides necessary sensitivity control adjustments for the device. The variations in the resistance values of the LDR due to changes in its illumination causes the corresponding change in the voltage division obtained from the voltage divider. The placement of LDR in the device is such that normally it will be in almost complete darkness. So its resistance will be of the order of a few mega-ohms. When the LDR gets slightly illuminated due to the reflection of light from the smoke, its value will drop down to a few hundred kilo-ohms. This considerable drop in resistance value of LDR will increase the voltage across the lower part of the voltage divider. As this voltage is fed as the input to the amplifier, it will bring the first transistor in saturated condition, i e, the collector to emitter path is virtually shorted, and thus the voltage at its collector drops down to almost zero. This fall in collector voltage of the first transistor won't be able to keep the second transistor any more in saturated condition. This will remove the virtual shorting of the input terminals of the oscillator transistor and the oscillator will produce an audible alarm through its loudspeaker.

The lamp as well as the LDR are installed inside tubes having inside diameter of approximately 15 mm. The length of both the tubes is approximately 100 mm. Both the tubes, projector and receiver, are kept at right angles to each other such that the LDR does not receive any light, either direct or reflected. The whole assembly is enclosed inside a suitably vented wooden enclosure so that though it has enough access for smoke to get in, it will offer sufficient obstruction to any external light source to interfere with the LDR. To avoid the problem of internal reflection of light, the enclosure, receiver and projector tubes have to be painted inside and outside with a black matt paint. When the smoke enters the enclosure it interrupts the light beam produced by the projector. The light gets reflected in all directions. Some part of this reflection illuminates the LDR and the device produces an alarm.

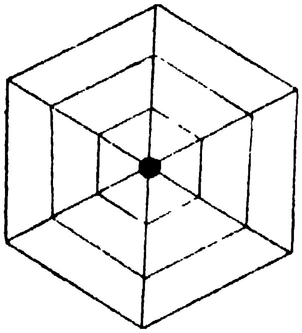
You will need:

Semiconductors: Transistors: BC 177, 2; AD 149, 1; *Rectifier:* BY 126, 1; *LDR:* 1; *Capacitors:* Paper, polyster or ceramic, 0·1 mfd, 1; 0·47 mfd, 1; Electrolytic: 500 Mfd — 12V, 1. *Resistors:* All half watt, 100K, 1; 33K, 1; 10K, 2; 1K, 1; *Potentiometer:* 100K, 1; *Transformers:* Mains: Pri: 230 V.A.C., 1; Sec: 6·3 V.A.C. at 500 mA, 1; Output: Push-pull, Pri. matching with transistor AD 149, sec. matching with loudspeaker used; Loudspeaker, 3 to 8 ohms — 1 watt, 1; Lamp, 6·3V — 300 mA, 1; On-off switch, 1. Lug strips or group board, wires, solder and screws.

Anil V. Borkar

brain teasers

SMART SCHOOL BOYS: A series of roads, as indicated in the lines in the figure, surround a boys' school, indicated by the black dot in the centre. At each junction point in this figure lies a bed of flowers, but no two beds have flowers of the same colour. Whenever a boy from the school is punished, he is asked to go around collecting one flower of each colour. A few of the smarter ones found the shortest route to do so. Could you join this cerebral group and trace the shortest route?



Om P. Goyal

GARDEN PATHS: Two brothers have two gardens of equal area, one being a square and the other, a rectangle. Each of the gardens has a one-foot wide path, dividing it into two equal parts and running parallel to one of the sides. The area of the path in the rectangular garden is more than that of the path in the other garden by one-third of its area. If no side is longer than 20 feet and no fractions of a foot are involved, what are the dimensions of the two gardens?

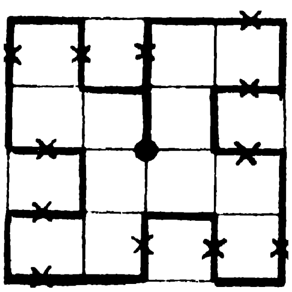
SHOPPING PUZZLE: I went to a department store with my wife. I had some money; my wife had some more money, and neither of us carried any coins. With my money I could buy either five ties or seven face-powder tins. My wife could buy either eleven face-powder tins or five lipsticks with hers. Then we bought the same number (more than one) of the three articles and found that we were left with Rs. 21, just the amount required to pay the taxi fare to return home. How many ties, face-powder tins and lipsticks did we buy and what was the price of each? (All the prices were in rupees and in round figures.)

V. A. Shenai

(*Solutions next month*)

Solutions to last month's Brain Teasers

Milk supply problem



Twelve milk booths will be required. They are indicated by crosses in the figure. The route of the truck is shown in thick lines. (This solution is purely based on the judgement, therefore there may be more than one way.)

Trousers and shirts

Let X trousers and Y shirts be ordered. Then there are $\frac{2X}{3}$ good trousers and $\frac{Y}{2}$ good shirts.

These are equal:

$$\frac{2X}{3} = \frac{Y}{2}$$

$$\text{i e, } \frac{X}{Y} = \frac{3}{4}$$

The minimum values for X and Y are 3 and 4, respectively. This makes a total of 7 garments ordered. For this to be a perfect square, the total number of garments should be 7^2 (i e, 49), 7^4 (i e, 2,401) etc. When it is 49, there are 21 trousers (7 rejections) and 28 shirts (14 rejections). If we consider 2,401 garments, the number of rejected shirts exceeds 15, and hence the answer is, 21 trousers and 28 shirts — a total of 49 garments.

Factory working

To get the maximum wages in a 12-hour shift, one has to work as early as possible and stop work as late as possible. One combination would be, coming at 1·00 pm and starting at 1·02 and stopping at 12·48 am the following day. This way, one gets wages for 11 hours and 46 minutes. One can get the maximum wages if one comes at 2·00 pm, starts work at 2·04 pm and stops at 1·59 a m the following day, thus getting the wages for 11 hours and 55 minutes. If one starts at any other time, one gets less wages. Hence, one has to start at 2·04 pm and stop at 1·59 am the following day.

••

Mr. R. S. Hulyakar of Bombay writes:

The " Thesis Puzzle " in the August 1973 issue was beautiful and engaging. I solved it within half an hour or so.

The solution given for the brain teaser " Who is the thief? " (July '73) is not at all satisfactory. In the problem given, it was clearly stated that only one of the given three was the thief and only they were taken into police custody. Then how did the lady of the house come into the picture? A better solution will be " any outsider " also.

For the puzzle on " Cups and Saucers " (August '73), my answer comes to " 80 cups and 85 saucers ". In that case, the wording of the problem will be " they had already sold some sets as well as some more cups " (and not saucers).

[*Dr. Shenai writes:* I had never mentioned that only one of the servants is the thief. A reference to the carefully worded problem shows that the police found that no *outsiders* (other than the servants) were in the house, apart from the lady of the house. According to the statements of the servants, none of the servants is the thief, as proved in "Answers" (August '73). This leaves the lady of the house herself as the real thief, who obviously had lodged a false complaint with the police to cover up her crime!

Regarding Mr. Hulyakar's comments on the puzzle on "Cups and Saucers" (August 1973), there had been an unfortunate error (which was corrected in the September 1973 issue) in the puzzle itself. As stated (with the error), the puzzle cannot be solved, since, when there are seven unbroken saucers, it is not possible to serve 44 people with tea *simultaneously.* This being the case, I wonder how Mr. Hulyakar solved it.]

FORTHCOMING ISSUES

HOUSEFLIES

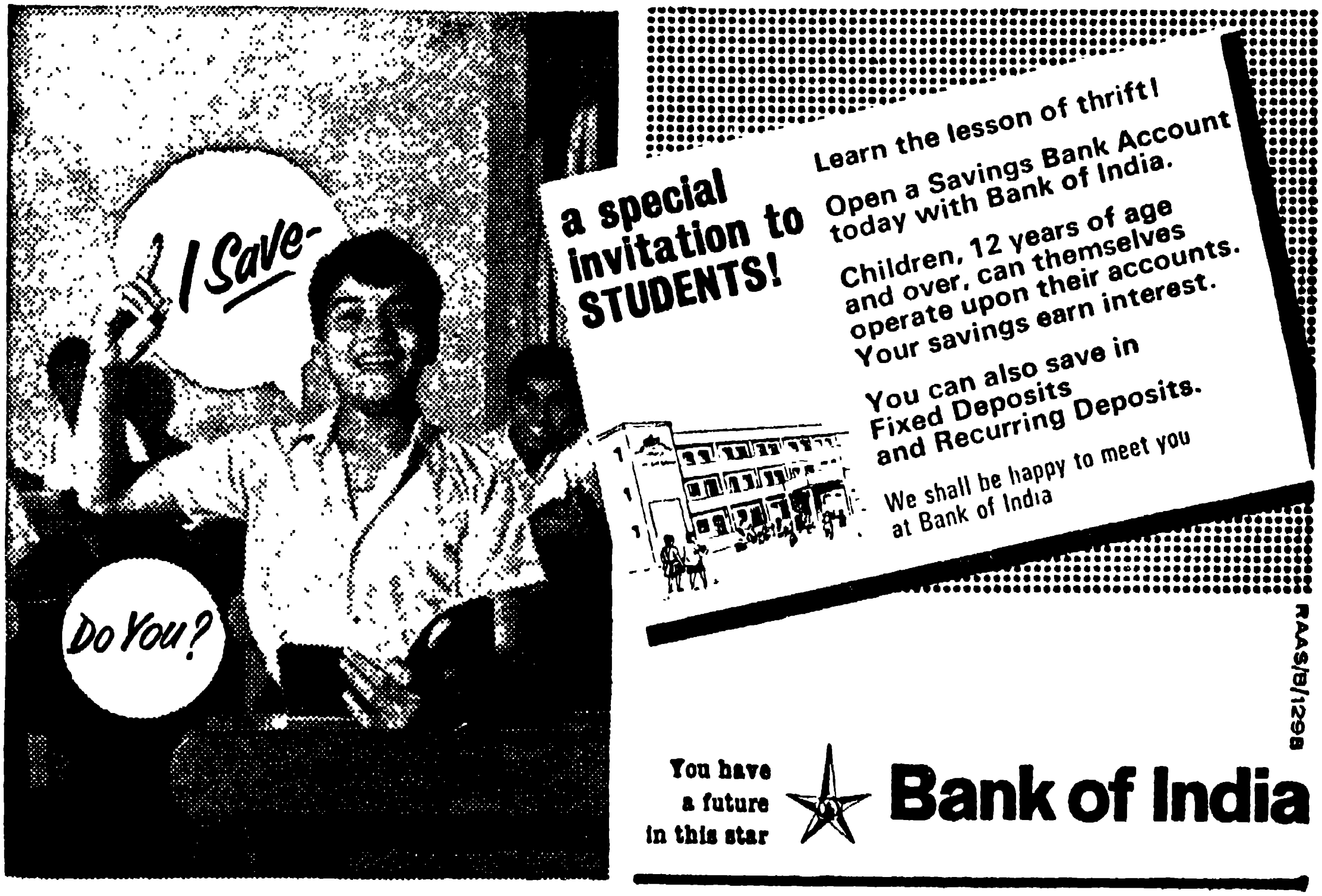
COMET KOHOUTEK—ASTRONOMY'S CHRISTMAS GIFT

THE SHAKING MINARS OF AHMEDABAD

COMPUTERS IN INDIA

DROWNING AND RESUSCITATION

FOCUS ON PETROLEUM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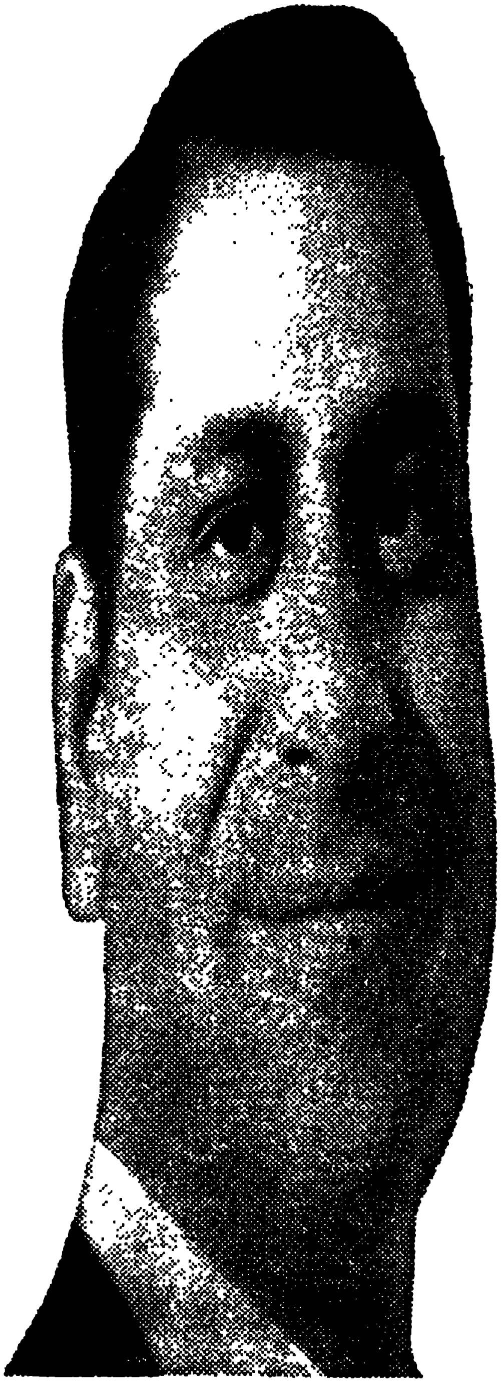

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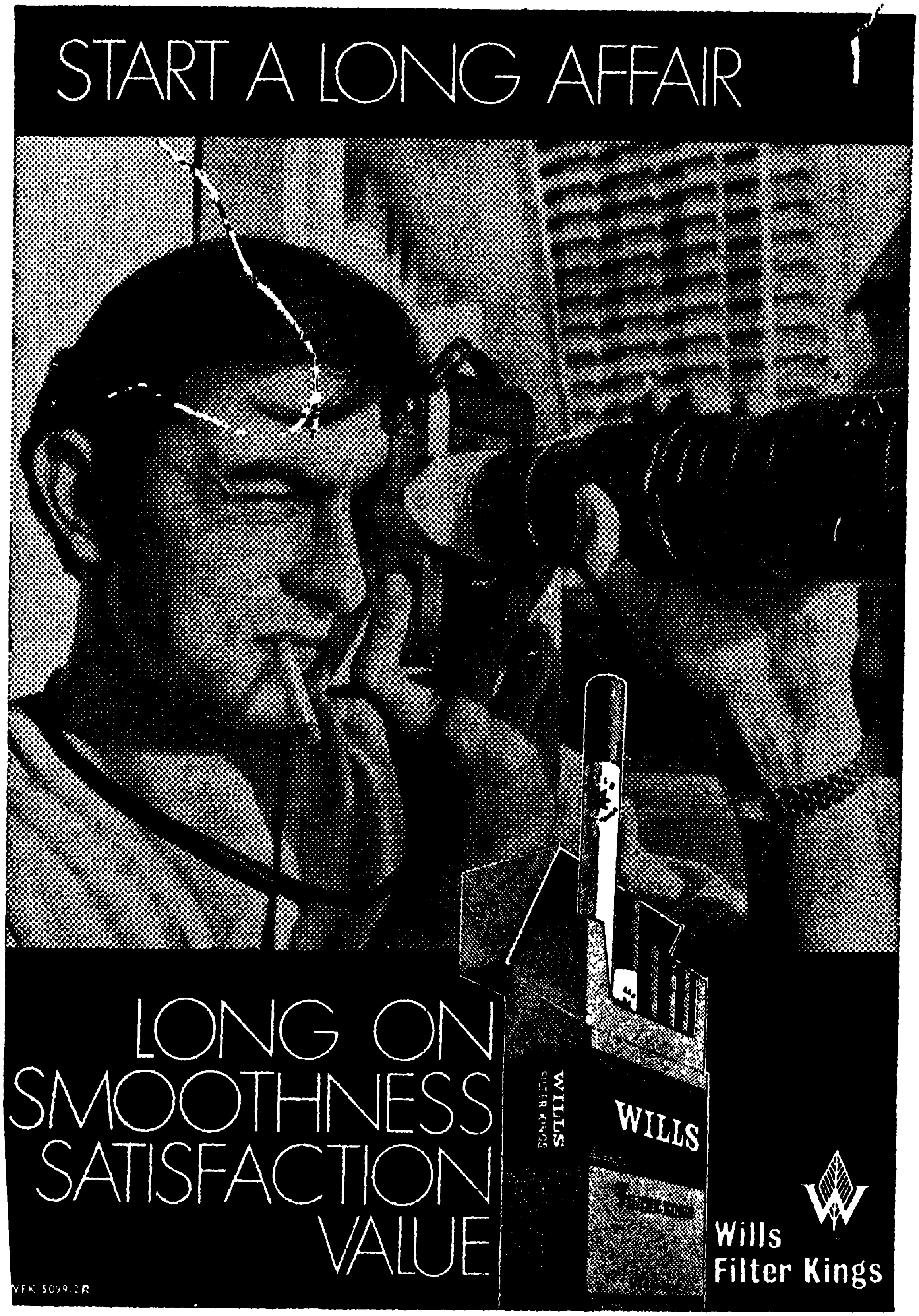
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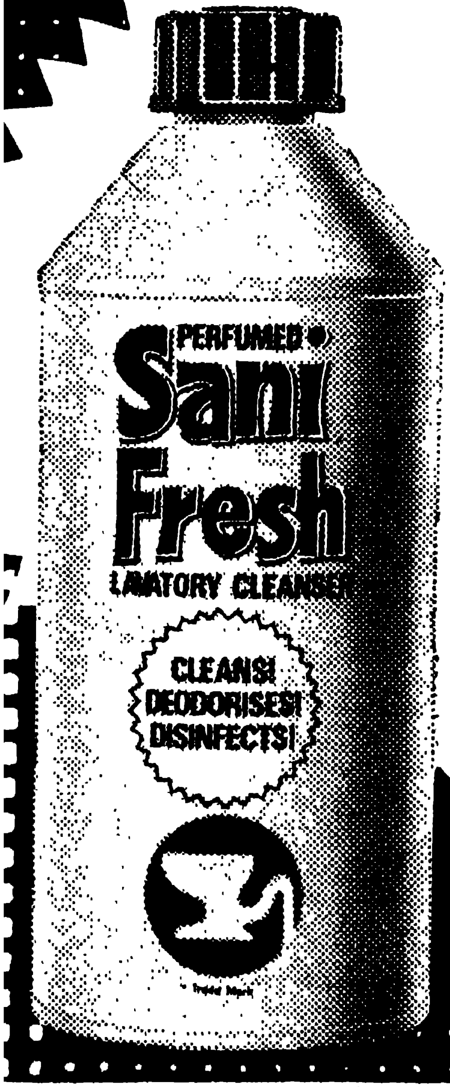

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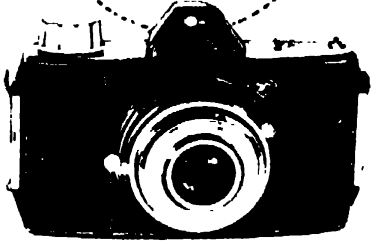

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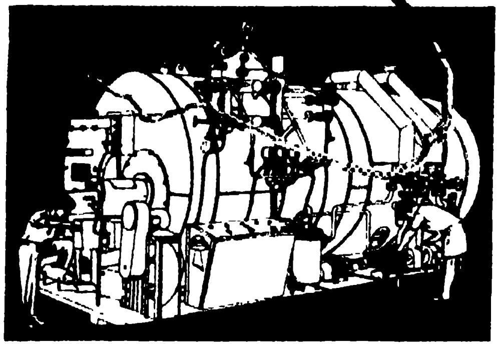

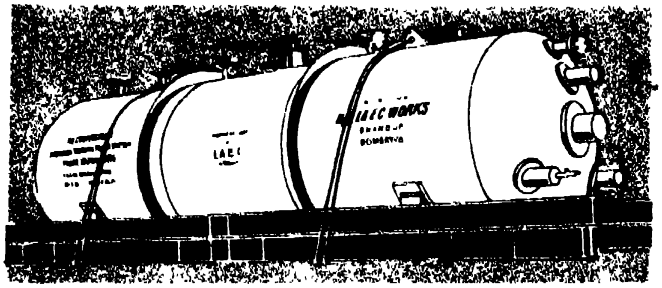

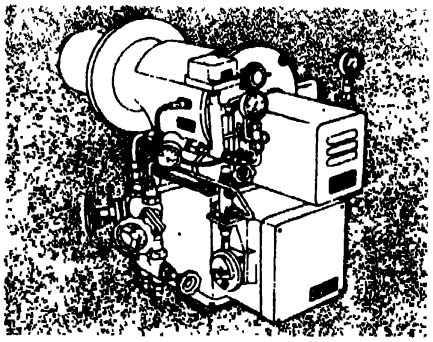

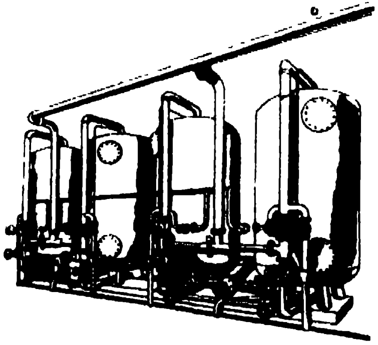

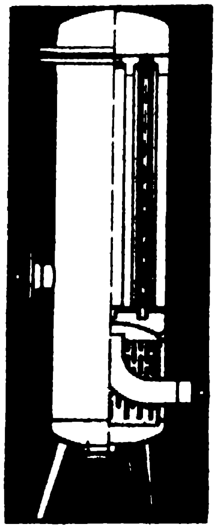

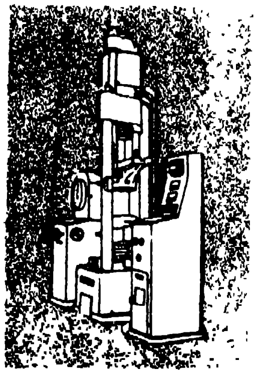

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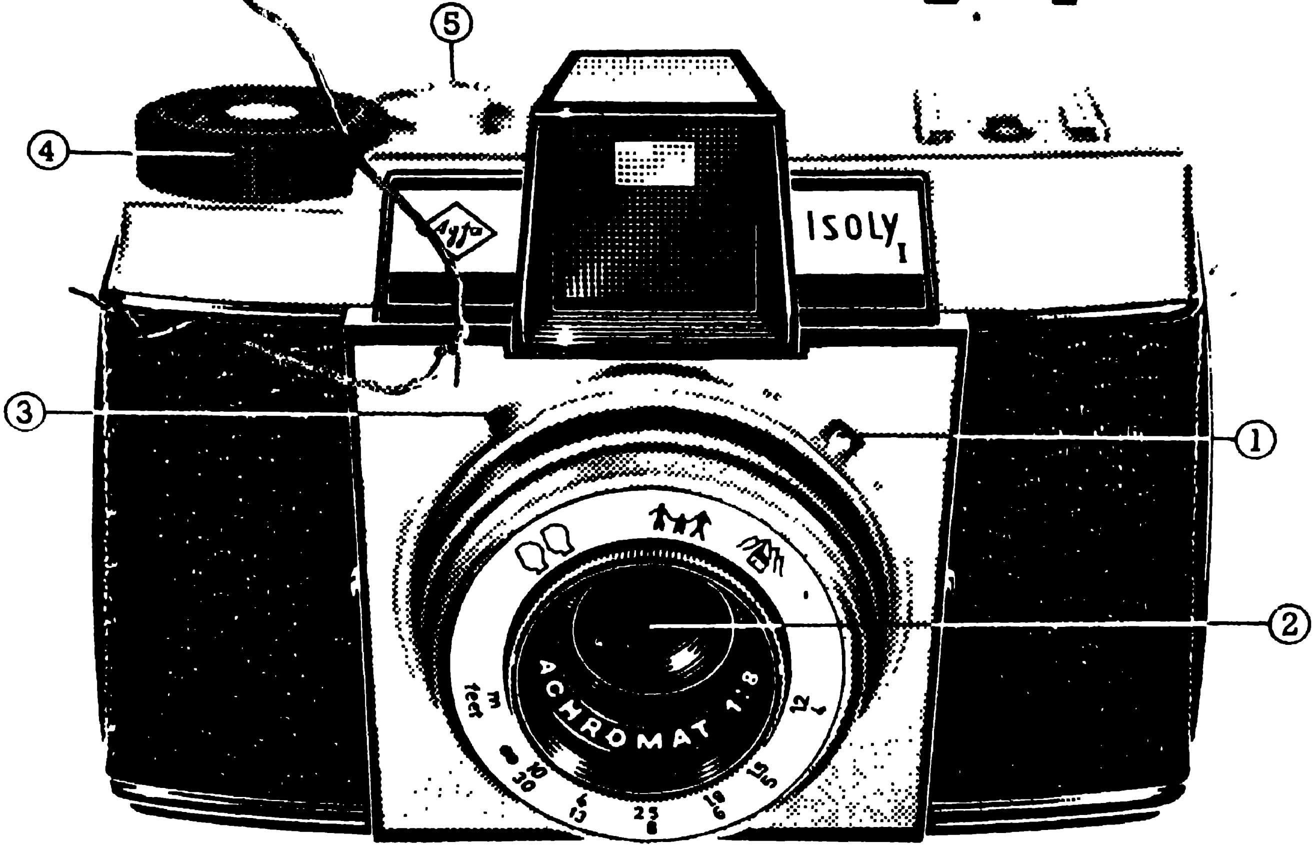

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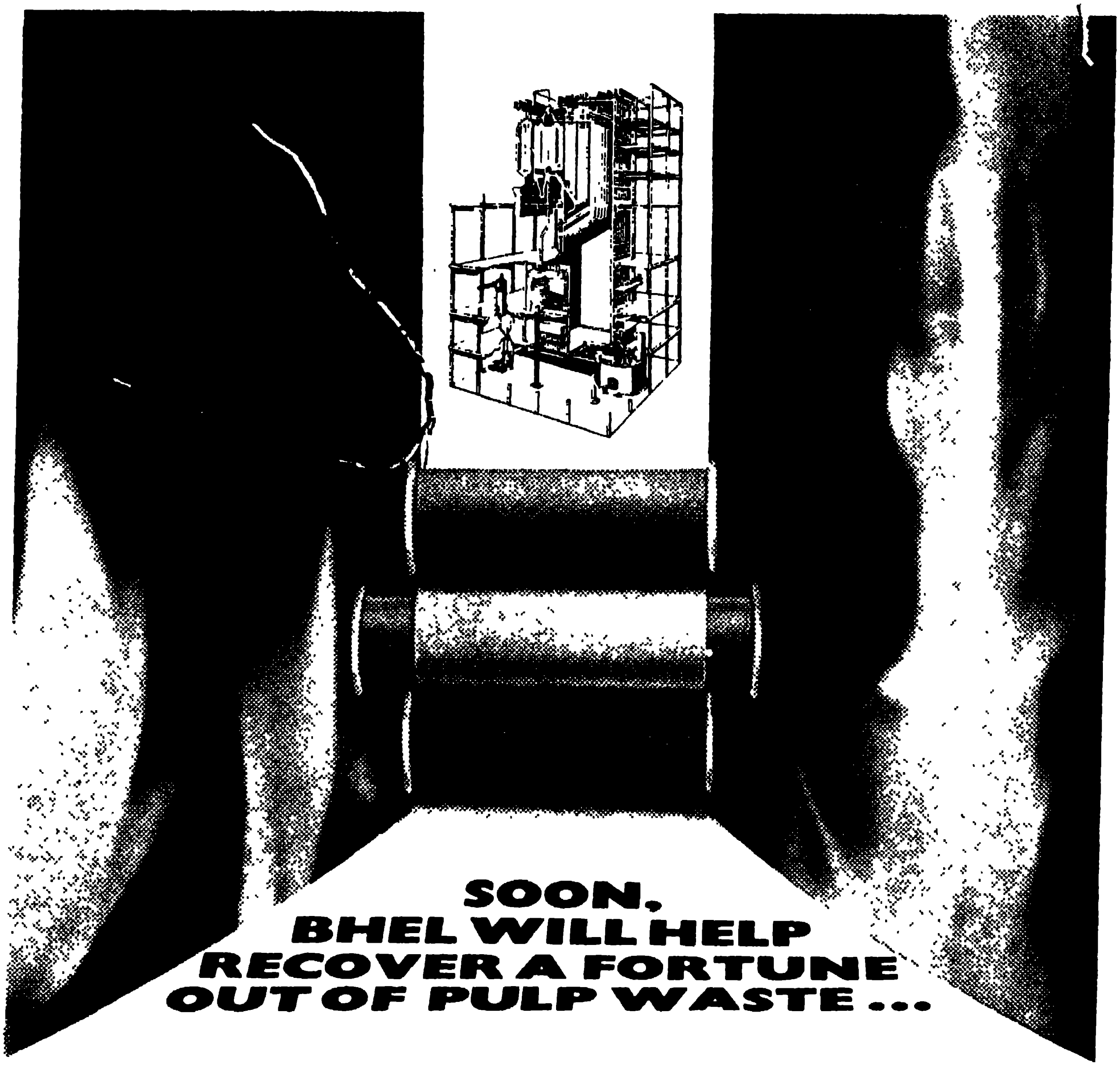

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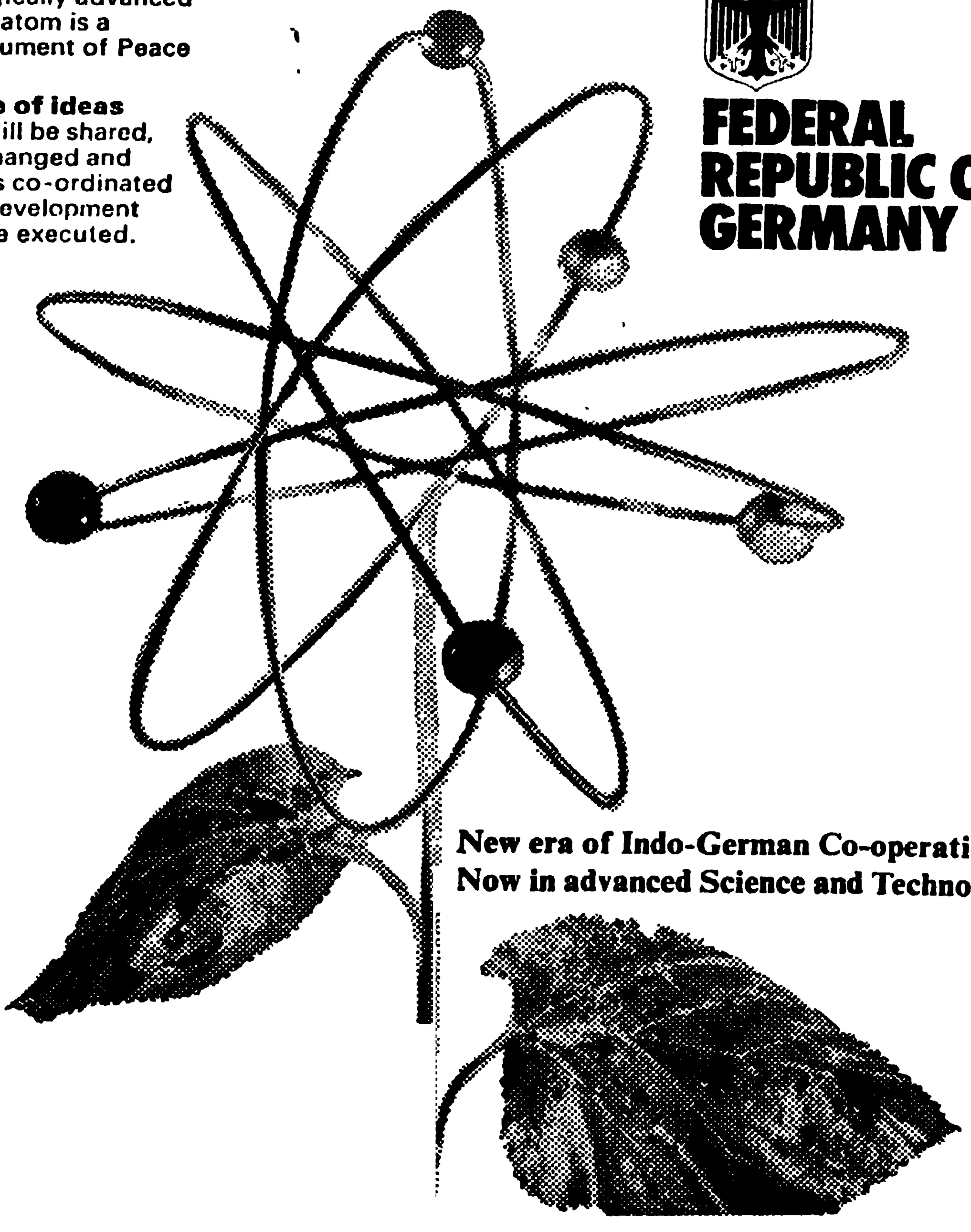

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VOL. 8 NO. 6
December 1973

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EDITOR
SURENDR JHA

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our unscientific search for OIL

B. G. DESHPANDE

THE phenomenal rise of petroleum price has hit the whole country, directly or indirectly. In 1972, India produced 7·4 million tons of crude; we imported much more, about 12 million tons. Now the import bill has gone up from about Rs. 130 crores in 1970 to over Rs. 500 crores at the present bloated prices. It may go up still further. All our suppliers have raised the prices. Simultaneously, the West Asian countries, which have 60 per cent of the world's proven oil reserves, have cut down production by 25 per cent creating a world oil crisis.

The Government was quick enough to raise the prices of petroleum products, apparently to curb consumption. Why is it that like in droughts or floods, we wake up only when there is an immediate crisis? We were well aware of the world political situation. Could we not anticipate the oil crisis?

Of course, there are some beneficiaries — the oil-exploring organisations, ONGC (Oil and Natural Gas Commission) and OIL (Oil India Ltd). For both, the price they get for the crude they produce is based on import parity. So their coffers will now swell; next year, the books will show higher profits. In the ultimate analysis, the Government will get a windfall of unearned income.

Comments on the oil crisis so far have underlined its financial and commercial aspects. Only a very oblique reference is made to our own efforts at oil exploration and production. The presumption seems to be that all that can be done is being done. Is it?

Oil prospects in India have been evaluated by many experts, in different ways. Estimated prospects vary between 500 million and 1,000 million tons. The Russians who had done a survey have been holding high hopes of 'big' oil in India, both on land and offshore. But except for the early successes in Gujarat — Ankleshwar, Cambay and Kallol — and Assam during the seven years from 1956 to 1963 (3·5 million tons), the last 10 years have seen very little exploratory success — not more than half a million ton.

We seem to have found nothing significant even in the western region of the country where we have our bonanza — the Ankleshwar oilfield. And it is unlikely that there are no other fields comparable in magnitude to Ankleshwar Could it be that our own earlier geophysical data have not been utilised properly, and fully, in prospecting for oil? Till recently, there was a severe back-log in the interpretation of geophysical — especially seismic — work done between 1963 and 1970 by the ONGC. Even the Malaviya Committee was compelled to highlight this lacuna. In this background, the surprise is not that we have not found more oil but that we have found even this much.

WHERE ELSE CAN we look for oil? World over, the offshore holds the best hope. I. G. Weeks, an American authority on the subject, believes that about 80 per cent of the world's potential, as well as proved, oil reserves exist beneath the continental shelf. The best parts of most coastal basins lie offshore, mostly in Mesozoic (150–240 million years ago) and Tertiary (13-60 million years ago) rocks. However, less than even 5 per cent of the world's offshore area has been prospected so far.

What have we done about the offshore? In Aliabet, our first offshore venture in the Gulf of Cambay three years ago, we did encounter oil, but the first well did not show commercial prospects and the efforts were given up. We shouldn't have let this happen. Aliabet has an advantage: it is close to the shore (about 3·2 km) which makes it easier to produce oil or gas from it. The fixed drilling platform was supposed to be capable of being shifted and used for drilling other locations as well. But even after three years, the platform lies abandoned at the site. Why?

Reports from the ONGC had suggested that the oil came from the Miocene (25 million years old); if this is so, this would be one more discovery which needs to be followed up in other parts of the Cambay basin where oil has been found so far only in the Eocene (70 million years old).

TODAY OUR EYES are on the Bombay High where drilling has just started, though it was discovered in 1965. It is now reported that the mobile drilling ship *Sagar Samrat*, bought from Japan at a cost of Rs. 15 crores, could not anchor on the originally selected, best part of the Bombay High because of the mechanical inadequacies of the ship. Apparently, the legs of the drilling ship could not take the load within the specified depth on the seabed; this is important because excessive penetration can subject the platform to greater wave action.

How reliable were the seabed investigations? The order for the ship was placed even before the contract for seismic work was awarded. This was putting the cart before the horse. Normally, one would have expected the seismic work to be completed first. The specifications of the ship should have been worked out only after selecting the sites.

The Bombay High could not be drilled. Drilling is now going on at a side structure called Tarapur.

Any structure in the western region is capable of giving oil and/or gas. We may find oil at Tarapur. The question is how does it compare with Bombay High geologically? Early surveys have indicated Bombay High is a bigger structure. Yet we chose a smaller prospect in place of a more promising one because the drilling ship could not anchor.

Certain other questions arise too. Like, if seabed investigations, done by foreign experts, have not given reliable results and have caused drilling to be put off at Bombay High, how are we to be sure that the seismic work — also reported to have been carried out by foreign experts — and its interpretation are dependable? After all, on this depends the strategy of drilling.

OUR PLANNERS seem to have reconciled to the ONGC's view that there is not much oil to be found in Indian soil. We are planning exploration in foreign countries in a big way. But then, instead of looking up to the skies and across the horizon, should we not look closer under our own feet? Today, our best hopes are in Bombay High. We must drill it at all costs, within the shortest time, either by modifying the ship, if necessary, or by using another ship.

A crisis of leadership . . .

"THE critical comments should not be taken to mean that ONGC lacks talented people. But we find the ONGC's leadership highly deficient and the atmosphere of work vitiated," the Malaviya Committee for Review of ONGC reported last year.

What the committee mainly found was a crisis of leadership, lack of adequate planning, conflict between inter-related disciplines and wrong field priorities. "After the first set of top leaders was gone, the management fell into incompetent hands who set a wrong tone. By putting wrong people in position down the line, they did permanent damage."

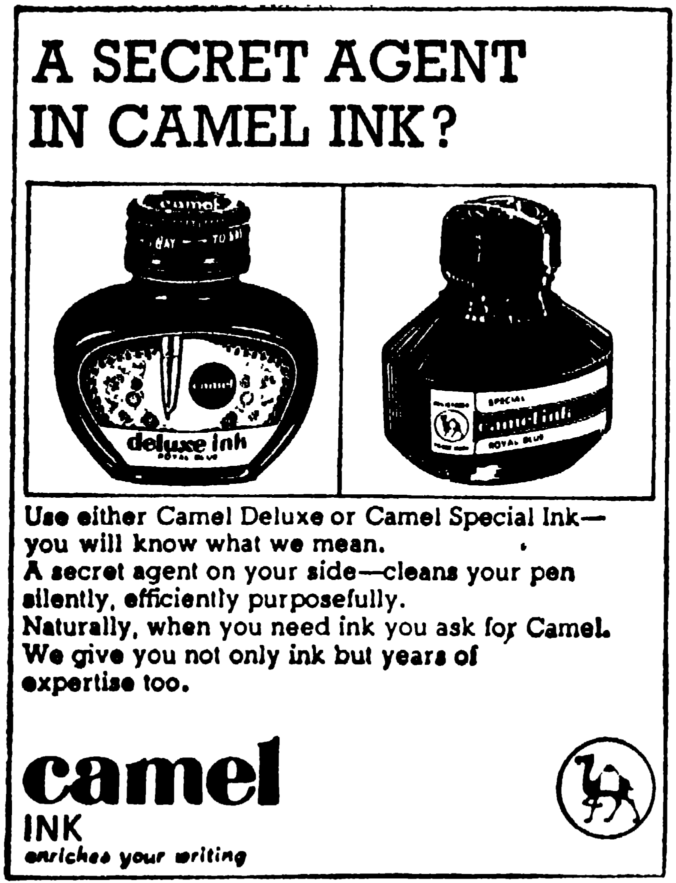
"The Committee finds that there is no unity of purpose among the members of the Commission. The Member in charge of exploration does not have the outlook of an explorationist; and the other members, inducted from outside the oil exploration industry, lack the necessary background. Since they have to depend for guidance on the directorates they are supposed to control, and do not have either the time or the inclination to cross-check the advice received, they function as departmental heads."

These remarks have particular relevance when the country is facing an oil crisis and the Government is looking for a suitable man to lead the ONGC. Would the past mistakes be avoided now?

It is also possible that we may not find oil at Bombay High. In that case, we must move to other offshore areas, including areas off the eastern coast, in the Bay of Bengal, the Andamans, etc. Though our land prospects are fairly promising, offshore prospects are better. It is true oil exploration is a gamble, more so the offshore probe. To avoid the pitfalls, we shall need a thoroughly scientific approach.

It is also necessary, in our own long-term interests, that we develop our own expertise. Are we utilising the talents within the ONGC? Much of the ONGC's work today is carried out under cover of secrecy. For instance, the ONGC should have voluntarily come out with the difficulties it encountered in drilling at Bombay High. And if the ONGC fights shy of communicating, at least the Government should have shared the information with the public so that there is a healthy, open debate on a matter of such crucial national importance.

Dr. Deshpande is professor of geology at the University of Poona. Earlier, he was with the Geological Survey of India, the Indian Bureau of Mines and for 15 years with the ONGC as the Chief of Geological Services.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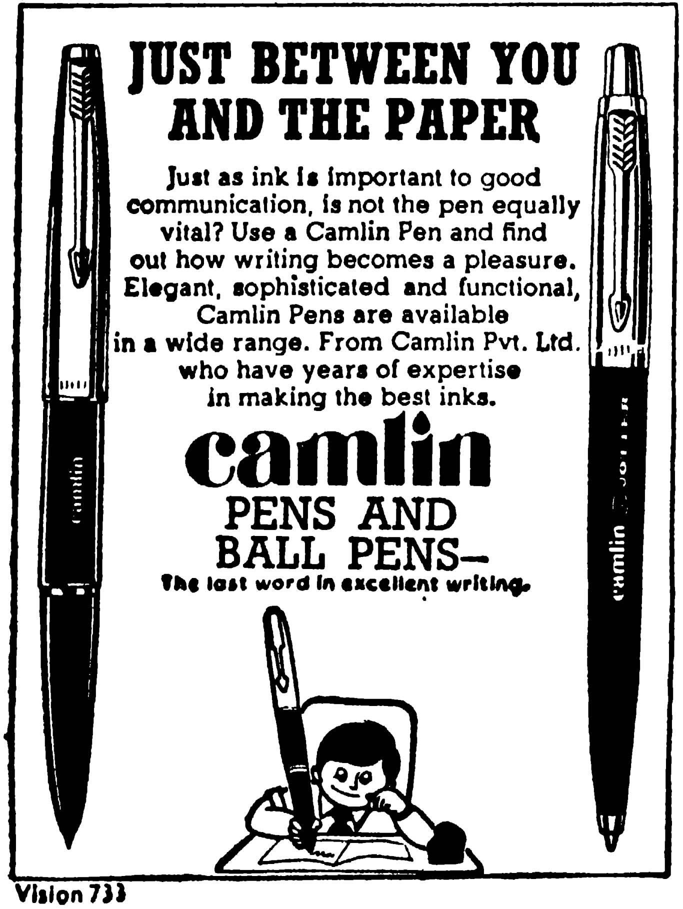
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letters

On a wild goose chase?

NONE of the distinguished "dairy 'experts" who have answered your questions in the special issue on "All about Milk" (September 1973) has really touched the basic problems of the dairy industry. For example, it is doubtful whether the milk production figure of 20 to 25 million tons a year, which we have been hearing for the past several years, is correct. If this assumption is wrong, all future projections will naturally be wrong. According to earlier official statements, we should have had 30 to 35 million tons of milk in 1971. Now we are told that this will happen at the end of the Fifth Plan in 1978-79. And since nobody will remember what is said in the Fifth Plan, it would not be surprising if similar statements and figures are repeated in the Sixth Plan.

The biggest problem is unproductive and useless cattle. Unless these are slaughtered, there won't be enough feed for the productive and crossbred cattle. Political expediencies should give way to pressing economic considerations. We have now imported different breeds of cattle from different countries — Denmark, Holland, Switzerland, Australia, New Zealand, Canada, US, UK, etc. Unless crossbreeding is done carefully, based on a meaningful national policy, we may end up with nondescript cows. Besides, the crossbred animals are more susceptible to disease and infection, and we are short of serums for foot-and-mouth disease and rinderpest. We would need more vaccines to be made available to the farmer free of cost, and also a large network of veterinary services.

The practice of paying the milk producer on the fat content of milk has encouraged the production of high-fat buffalo milk and discouraged the production of cow milk which has comparatively a low fat content. The most important contents of milk are protein, lactose and some vitamins, or solids-non-fat (SNF). If we are to encourage crossbreeding, the farmer must be paid on the basis of SNF (preferably protein content) on a cost plus basis.

Dr. Sam H. Dalal
Bombay

A way out of the power crisis

In the article "Total Energy Concept for More Power" (October 1973), the authors have highlighted the chronic power crisis in India in a most telling and commendable manner. The application of the concept will certainly help us out of the doldrums.

Bala Kolangara
Bombay

science shapes life

An ice well in the sea?

It has not been done yet, but can be, according to a British patent granted to Kenneth Langner of UK. Langner's idea is to lower a concrete ring from a floating platform to the sea or riverbed, guided by coiled steel tubes attached to the platform. A refrigerant will be pumped down the tubes which will freeze the water around the tubes thus making a hollow cylinder of ice. Unfrozen water from inside the cylinder can be pumped out. When no longer needed, the refrigerant can be withdrawn, the ice will melt away and the steel tubes with the concrete ring can be hauled up.

Maybe a good idea for prospectors of minerals, oil or gas under water.

Pregnancy reduces immunity

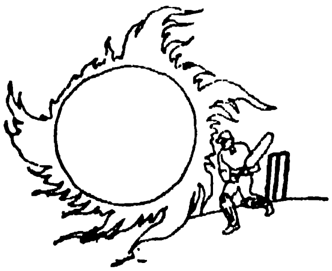
A foetus is a foreign body in the mother's womb. To prevent the body's defence mechanism from rejecting it, the immunity is naturally lowered. But this also makes pregnant woman more prone to attack of diseases.

Women are known to be particularly prone to severe attacks of polio, hepatitis and other viral diseases during pregnancy. One of the dread diseases is German measles. If contracted in the early stages of pregnancy, the baby may be born defective.

Pediatrician Y. H. Thong and his colleagues at the Georgetown University School of Medicine, USA, have found that a pregnant woman's cell-mediated defences against German measles is lowered. This means she has even more reason to avoid exposure to viral diseases. However, after the termination of pregnancy, the cell-mediated immunity of the mother is back to normal.

Play cricket when the Sun flares

Meteorologists have been speculating about the relationship between sunspot activity and weather for years. Now Dr. J. W. King of UK's Radio and Space Research Station at Slough has compiled data which show the connection may be "very strong". To the weight of evidence which includes records of the length of "growing season" — the time of the year when air temperature 1·25 m above the Earth's surface exceeds 5·6°C — he has added another more mundane: cricket scores! He has analysed the scoring records of cricketers in UK over the past 100 years and found that large totals come off the bats only when the summer is very dry. Seasons when individual scores topped 3,000 runs were years of maximum or minimum sunspot activity.



There is already some experimental support for King's theory. It is known that depressions at higher latitudes increase a few days after the arrival of solar particles in the atmosphere and the most affected region lies between 75°-79° N.

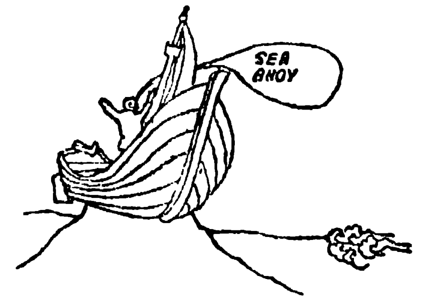
Dr. King has also found that North India has very reduced winter rainfall after periods of high solar activity. An analysis of a 274-year monthly rainfall record of Kew, Scotland, showed the exceptionally dry winters occur in periods of low solar activity. King feels this should be taken into account for long-range weather prediction.

Can stuttering be cured?

Why not? Two new treatment procedures are already established. One involving a miniature metranome set behind the stutterer's ear to pace his speech is being successfully used by American psychiatrists John Brady of the University of Pennsylvania and Charlotte Zitrin of the Long Island Jewish-Hillside Medical Centre. The other is built on breath management and has been developed at the Centre for Communicative Disorders of the University of Southern California, Los Angeles. The basis of the therapy is this: stuttering is looked upon as an "inability to coordinate the creation of vocal sounds with their articulation into speech sounds. Something happens to stop the flow of air at the glottis, an opening between the vocal chords. As a result, normal phrases are chopped into units as short as a syllable or a sound, repeated over and over".

The treatment seeks to slow down the speaking rate. How? Stutterers use a Delayed Auditory Feedback instrument which plays back their speech with a time-lag of 250 milliseconds. Before they can go to the next word, they have to wait until they hear what they have already said. This waiting slows down their speech. The time-lag is gradually reduced and speech becomes faster. This training, the therapists claim, is very effective in developing stutter-free speech. But the stutterer must practise the technique constantly.

Sailing on land



After years of sailing the oceans, scientists have now developed a ship simulator. And, ironically, it has been developed by an aviation firm — the Brenet aviation and space flight enterprise in West Germany. The advantage? All ship manoeuvres can be practised without fear of wrecking. The simulator can reproduce every known ship movement: emergency turns, fouling and stopping, entering and leaving a harbour and even 'man-over-board' drills. It can be programmed to simulate three types of vessels: container ships, medium-sized freighters with passenger accommodations, and 250,000-ton supertankers.

Is cancer infectious?

There is a forerunner to this question: is cancer caused by a virus? The answer may be, yes, according to a remarkable experiment conducted by Dr. Sol Spiegelman's team at Columbia University, USA. Two sets of identical twins were studied; in each case, one twin had leukaemia while the other was healthy. When they looked at the cells from the affected twins, the scientists found virus-like particles which were totally absent in the cells from the healthy twins.

This means, says Spiegelman, the virogene theory is out. According to this theory, the cancer-causing RNA tumour virus can make identical DNA copy of itself (called a provirus) and can then get integrated into the host's genetic material. This integrated provirus is called a virogene. The parent can then pass it on to the offspring.

In Spiegelman's experiment, the healthy co-twins were virogene-free. If the leukaemia were inherited, even the healthy co-twins would show the integrated virus. That they don't means the virus in leukaemia cells is there simply by infection.

Learn to live with pain

Then you'll need less of analgesics too. Wilbert E. Fordyce and his co-workers applied Skinner's concept in combating chronic pain. It was (B.F.) Skinner's idea that conditioning can modify one's behaviour.

Fordyce and his team of rehabilitation medicine specialists at the University of Washington School of Medicine, USA, treated 36 patients with chronic pain. In a four-year study, they tried to lessen the pain by conditioning. The patients were asked to cut down on pain-killers, increase exercise and to work and socialise more. Above all they were discouraged from discussing their pain. At the end of the study period, the patients suffered less pain.

However, more investigations are necessary to brand pain as a learned behaviour rather than a physiological pathology.

Props for sagging bones

Osteoporosis is a common complaint of old age. The bones lose mass over a long period and become more susceptible to fractures; fractures of the ribs and hips are more frequent as a result of this bone loss. Pain in the lower portion of the spine is another complaint. In post-menopausal women, the treatment consists of making up for the body's sinking oestrogen levels. This treatment is accompanied by large doses of calcium, sometimes along with vitamin D and fluoride. The results of such treatments are, however, disputed.

Jenifer O. M. Jowsey of the Mayo Clinic in UK reported her

Good-bye shellfish?

Where will snails live if the building materials for their homes on their backs are snatched away ? Or, where will the pearls for milady come from ?

According to Dr. A. W. Fairhall, Nuclear Sciences Institute, New Zealand, this will come to pass if carbon dioxide output keeps increasing. He forecasts that by the year 2008, shell production would be almost nil.

The carbon dioxide in the atmosphere has gone up by only 10 per cent in the last century. It is obvious, therefore, that there is a sink for the rest. When the gas reacts with the mineral, calcium carbonate, it forms a bicarbonate. (The mineral is the prime building material of shells. The bicarbonate cannot be used.) The chemical reaction will take place as soon as the gas content in the ocean goes beyond 41 ppm (parts per million). This fall should be noticeable in the next five years, says Dr. Fairhall.

By the way, don't take it too seriously, Dr. Fairhall adds; his forecast is based just on numerical exercises.

RELIC OF THE SHELL AGE.

studies at a seminar on nutrition held in Washington, USA. It is not the amount of calcium alone, but the ratio of calcium to phosphorus in the body that is related to the onset of bone loss, she says. In animals, Jowsey and her colleagues found, if the ratio was more than one, bone is lost. From this she concludes that foods like milk and cheese that have higher proportion of phosphorus than calcium will be useful in the treatment of osteoporotic patients.

Groovy roads

Slam the brakes on a wet road, and you can't prevent skidding. Many different road surfacings have been tried; the groovy surface is a new one.

Developed by the Cement Association of UK, the concrete road is inlaid with grooves at irregular distances. The grooves run horizontally across the road—a grooving machine follows the concrete-laying machine and presses in the grooves six millimetres deep and wide. These dimensions increase the life of the channels. The random spacing cuts down the whining and whistling produced by equidistant grooves.

These antiskid grooves serve two aims: they drain away water from the road surface and also provide an escape route for water trapped under the tyres.

And now, head transplants

Robert J. White, the chief neurosurgeon of the Cleveland Metropolitan General Hospital, USA, has successfully transplanted heads of monkeys. The recipient animals retained the ability to see, hear and smell and react to outside events. The hardiest of them lived for 36 hours.

Strangely there was no sign of tissue rejection of the brain. White attributes this to the strength of the blood brain barrier and the absence of lymphatic systems in the brain. (The brain and the bones are the only organs without the lymphatic system.)

In earlier attempts, White had isolated brains and kept them alive on machine — the maximum was under eight hours. He was also able to transplant the brain into the host animal; but, though the brain was alive, it lacked control of functions.

The 4- to 5-hour-long operation followed by intensive care by a 15-member staff is not a preliminary to human head transplants. According to White, the head transplant is part of a plan to study the involvement of the brain beyond the control of the nervous system.

Studies by White and others show that the brain plays a significant role in the production of hormones. This activity was previously attributed to certain glands alone. With the isolation of the brain, " there is no other organ in the circuit . . ."

ARE YOU SURE THE BODY IS OKAY?

Highest US Chemistry award for Khorana

Dr. Har Gobind Khorana seems set for accolades galore. Born in Raipur, India, in 1922, he won the 1968 Nobel Prize in Physiology and Medicine with Marshall Nirenberg and Robert Holley. Next year he won the American Chemical Society's Award for Creative Work in Synthetic Organic Chemistry. Now he has been awarded the Gibbs Medal — one of the most prestigious chemistry awards in the US — for " outstanding research on the synthesis of polynucleotides and on the nature of the genetic code".

His early work was done at the University of British Columbia at Vancouver (1952-60) where he used carbodimide reagents to synthesise many compounds including coenzyme A and other nucleotide coenzymes. Later, at the University of Wisconsin (1960-70), he did his Nobel-winning work on the chemical synthesis of complex polynucleotides containing known sequences of nucleotide bases. This helped clarify major aspects of the genetic code.

Shortly before leaving the University of Wisconsin in 1970, he announced the synthesis of a yeast gene that produces the transfer RNA specific for the amino acid alamine (it took him 5 years). The gene, consisting of a double-stranded DNA molecule, contains 77 nucleotide base pairs. Recently, he reported the synthesis of a more complex gene which — found in the bacterium *Escherichia coli* — has 126 nucleotide base pairs and is specific for the amino acid tyrosine. His current work: "We want to understand the chemical nature of these two types of regions — the initiator and terminator regions — that regulate RNA formation from DNA. Eventually, we hope to synthesise these DNA segments".

He is now Alfred P. Sloan Professor of Biology and Chemistry at MIT. He does not teach there, though; his research is full-time.

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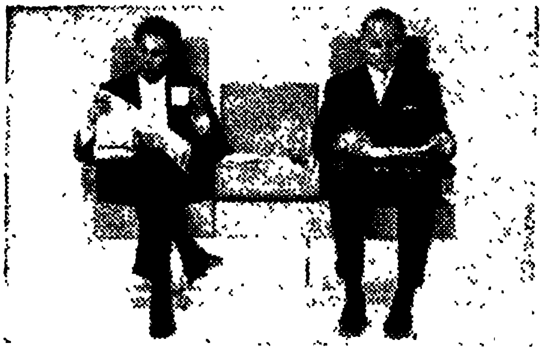

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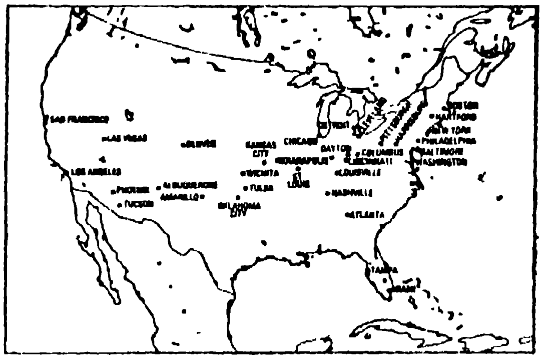

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HOUSEFLIES:

R. N. SHARMA
&
K. N. SAXENA

NEWER HORIZONS IN BEHAVIOUR CONTROL

THE flies are everywhere. As a nuisance, they are unmatched. They buzz man to distraction and often sow the seed of his destruction — sometimes of whole populations — by spreading such gruesome diseases as yaw, cholera, typhoid, dysentery and infective hepatitis. Small wonder that extensive studies have been done on the biology of the housefly and methods of its control. And, in recent years, considerable work has been done on the behaviour of these flying pests. These studies are important: they satisfy the natural curiosity of pestered men and also prepare the basis for better control programmes, now that conventional insecticides have fallen from grace because of their ecological hazards.

Let us introduce the housefly. Latin name: *Musca domestica* L. Belongs to the order Diptera (meaning 2 wings) of the great class Insecta. (The dipterans are the true flies: they possess, characteristically, one pair of fully functional wings used for flying and another pair of ill-developed, vestigial 'wings' called halteres which aid in steering and stability during flight.) Blowflies, fruitflies, sandflies, etc are among the housefly's close relatives.

They start life as pale elongated eggs laid in clusters in compost, waste heaps, manure, dung, etc. Slender, whitish larvae hatch from the eggs and shed skin (moult) twice to become the familiar creamy white maggots in about 5 to 7 days. The maggots transform into quiescent reddish brown pupae from which the adult housefly emerges after 5 days.

The life of an adult housefly spans, on an average, barely a month by human reckoning. Yet, a fairly complete repertoire of its activities during this brief adulthood has been documented.

When the adult comes out of the pupa, it is a pale, albino-like creature with folded wings; the familiar greyish black tan comes on within the next half-hour. And even as the tanning proceeds, the wings unfold. During these early moments of its life, the housefly seeks protected, possibly shaded, preferably rough, dark surfaces. Once the wings are well unfolded, the fly is ready to go out into the world.

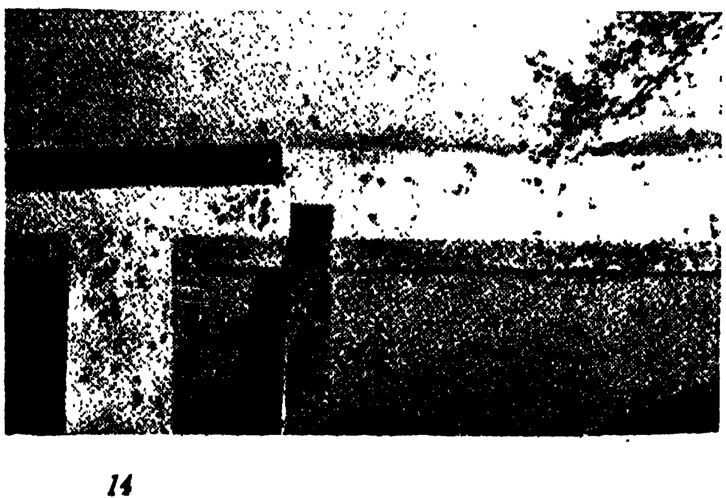
What does it do? Adult flies have two major preoccupations: i) search for food at all times, and ii) continuation of the species — search for mates and then search for suitable places/materials for egg-laying. Limited but well-defined ends; and unto these all the activities of these busy buzzers appear to be directed.

Flies must fly, but they don't fly for flight's sake. Casual observation reveals that a housefly may fly for varying periods of time, then alight on a surface where it may walk, rest, feed or lay eggs. That again depends on the nature of the surface and the fly's own 'mood'. The mood is important — it shows its internal physiological state, whether it is hungry, exhausted or gravid.

As we have noted, even the newly-emerged fly prefers to spend an hour of quiescence while its body is rapidly adjusting to the conditions of the 'outer' world. In later life too, the fly exhibits an astonishing degree of choosiness about where it wants to rest, what food it wants to eat and where it wants to lay eggs. Not that the choice is very limited — apparently quite a wide variety of substances seem to provide the fly's succour and sustenance. Thus, edges, projections (Fig. 1), suspended cords (e g clothes lines), etc are a frequent landing ground. Even resting or otherwise generally slothful animals like cattle and pigs provide resting surfaces.

As for food, anything will do, anything sweet or proteinaceous, syrupy, sticky and decaying organic matter, even sputum and faeces, pus from festering sores — all are good food sources. Of course, its choice egg-laying media are decaying and humid, often fermenting and smelly, humus/organic matters, for example, cow or horse dung, manure or refuse pits and carcasses.

Fig. 1 Fly aggregations on surfaces of different shades and textures. Note tendency to aggregate on edges, projections, dark and rough surfaces

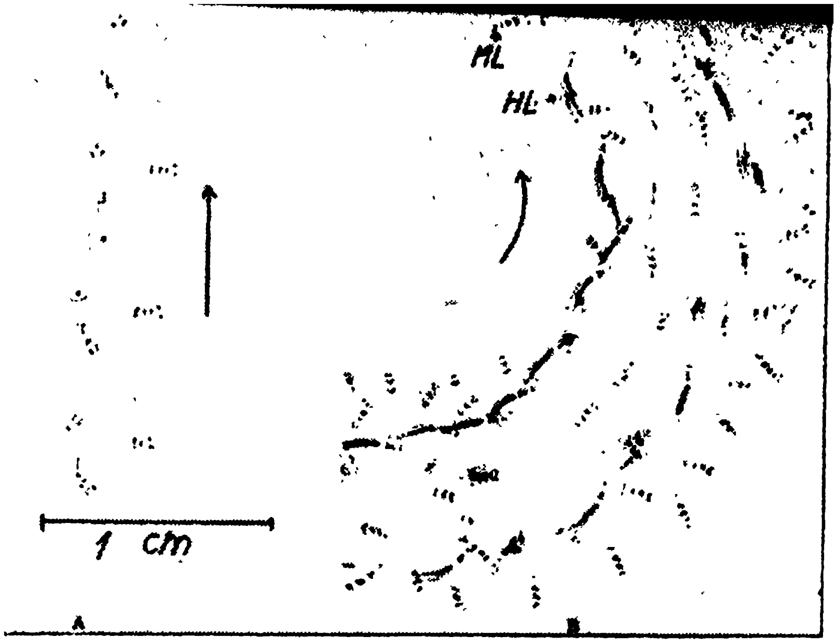


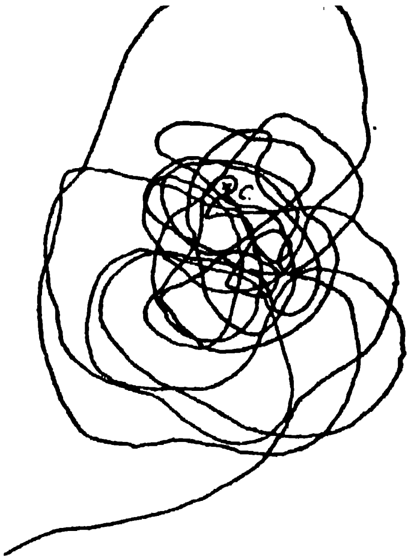
Yes, flies can be choosy about shelter, food or egg-laying substratum. And, remarkably, whatever they do is conditioned by signals or stimuli from various objects perceived by various sense organs. The stimuli may be visual (colour, form), smell, humidity, temperature, taste or touch. To a large extent, these stimuli coming from various sources determine fly behaviour. In fact, this stimuli-dependence is so important in fly behaviour that it has been the subject of intense and extensive investigation, in recent years.

PERENNIAL BUZZERS, flying, flying all the time. How long and how far will a fly fly? They have been shown to travel as far as 22 kilometres from their place of release, but usually they remain within 1 to 2 km of their original breeding grounds as long as there's enough food for sustenance and growth. Yet they may move away from a good food source, like flies have been seen to wander away from a veritable 'paradise of food' — the slaughterhouse. As a matter of fact, the flying or walking activities of flies may be random or they may be directed towards or away from an object. The random movements can be in varying directions — almost aimless — whereas the directed movements may occur as a result of attraction or repulsion by various stimuli.

The random movements involve short flights or walks in a series of straight lines in varying directions under conditions of more or less uniform distribution of ordinary natural stimuli such as light and temperature. Such 'aimless' ambulations may be mapped by making the flies walk on a sooted glass plate (Fig. 2A). To an extent, the meanderings of flies, or rather, the intensity of their random movements depends on their age, as also on their physiological state. For example, 1 to 2-day-old flies are generally more quiescent compared to older flies. Again, fully-fed flies are more inclined to rest in a cozy, dark nook instead of flitting about like the hungry ones.

The random wanderings continue until a fly has found a food source. If the food is tasty, such as sugar, the fly will stop and feed on it. If the food gets consumed or is removed before the fly feels fully fed, it goes into circling move-





Left: Fig. 2 Footprints on soot. Random meanderings (A) contrasted with more intensive and directed (circling) movements after brief stimulation by a food source (B). Right: Fig. 3 Not a 'find the treasure' puzzle but actual tracing of the circling movements of a fly after it has been stimulated briefly by an acceptable questatory stimulus (sugar) at C. Total time taken for movements recorded: 152 seconds

ments, describing repeated clockwise and anticlockwise turnings (Fig. 3) in quick short steps (Fig. 2B) in the area where the food was found. Even if the food is removed from its original position or if the fly itself is displaced to an entirely new location, it would make no difference. A fly which has tasted an acceptable substance will continue to perform these circling movements for some time. Of course, the duration and intensity of these movements depend on the quality of the food. A fly circling around is more likely to relocate food in the area than a fly walking or flying randomly. Circling movements of flies, so often seen on the dinner table, are thus associated with active food searching by a fly in an area where it has already perceived or encountered food beforehand.

After the fly has perceived the food source and circled around it for some time, it may go into directional movements towards or away from places or objects depending on whether it has perceived attractant or repellent signals from them.

FLIES SHOW appreciable preferences for certain types of surfaces for visiting them more frequently and staying on them longer. Experiments of J. Keiding and K. Arevad of Denmark reveal that the flies, given a choice of different surfaces in a cage, favour darker surfaces by more visits than light-coloured ones. Once it has chosen an object to alight upon, a fly prefers to stay longer on rougher surfaces such as jute sack, straw and canvas than on smoother ones like tiles, metallic or glass plates, etc. These laboratory demonstrations have been confirmed in field experiments too.

Tests involving coloured surfaces have shown that black and red surfaces attract more flies than yellow, green or blue ones. On the other hand, tests with different coloured lights have established that purple, blue and violet lights have a strong attraction for the flies. Ultraviolet, the so-called Black Light (since it is beyond the range of human visual perception), has the strongest pull.

Of smells and perfumes: the fly's choice

THE INFLUENCE of odours on the locomotory movements of animals, and insects particularly, has been recognised for a long time. Houseflies seem to prefer odours generally unpleasant to humans. The association between flies and filth is, in fact, odour-based.

We have said that when flies select a medium for egg-laying, they choose mostly decaying organic matter like dung, manure, etc. Smells emanating from these have long been suspected of playing an important role in attracting flies from a distance. As early as 1916, C. H. Richardson of USA showed that cotton or

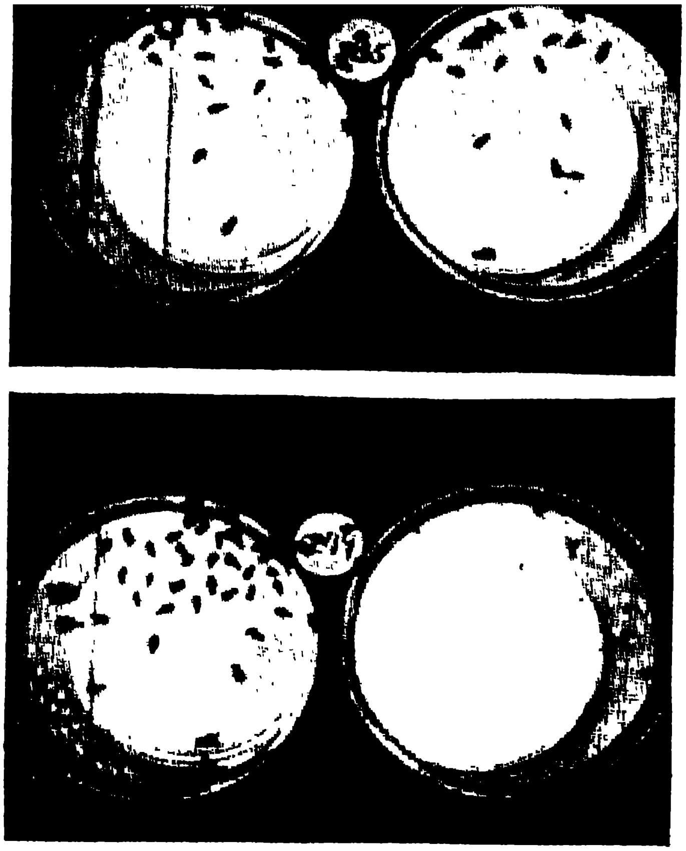


Fig. 4 Testing fly responses in an olfactometer. Top photograph shows equal distribution of flies when filtered air is passed through both ports. Photograph at the bottom shows aggregation of flies in the left port through which attractant (isovaleraldehyde) vapour was passed, contrasted with the extremely low fly number in the right port through which only filtered air was passed

filter paper treated with ammonium carbonate, valerianic or butyric acid — all of which occur in manures — could induce houseflies to lay eggs. Subsequently, various other salts of ammonia, especially ammonium hydroxide in certain favoured concentrations, skatole, isovaleraldehyde, etc were also added to the list of chemicals attractive to the housefly. In an experiment using an olfactometer, Prof. V. G. Dethier of Princeton University, USA, found that a stream of air containing the odour of isovaleraldehyde attracted more flies than blank odourless air (Fig. 4). Another group of researchers led by Prof. A. W. A. Brown in Canada found that a mixture of malt extracts, ethyl alcohol, skatole and acetal in certain concentrations attracted flies much more than any of these components individually.

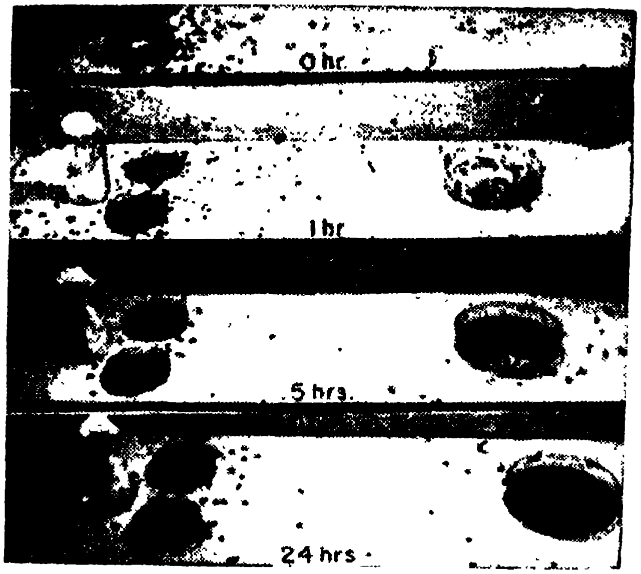


Fig. 5 Catch 'em by the tons. Laboratory demonstration of attractive capacity of chemical (1, 3 diolein) isolated from mushroom by Muto and Sugawara of Japan. Petridishes at left contain the attractant

More recently, a Japanese team working on the premise that some mushrooms seem to attract houseflies was able to extract a chemical called 1, 3 diolein from the mushroom *Amanita muscaria*. It gave a creditable performance as a fly attractant in a laboratory demonstration (Fig. 5). In view of the fact that most fly attractants hitherto discovered/synthesised have been noxious to human nostrils, the authors have recently been screening a series of naturally occurring compounds with more acceptable or even pleasant odours for their attractancy for houseflies and a few promising candidates have been found. The results are under publication.

Do flies carry attractants themselves? It has been seen that flies tend to aggregate at places where other flies are present. This led to the conjecture that some chemical(s) (pheromones) produced by the flies themselves could be responsible for such a mutual attraction. But isolation/identification of these pheromones is extremely difficult because they are emitted in infinitesimal quanta. In recent years, suspicion has focused on the possible existence of an aggregation pheromone and a sex pheromone. Very recently, Carlson and his colleagues in the USA have in fact isolated a sex pheromone from female houseflies and identified it as Z-9-tricosene. This chemical has now been synthesised as 'Muscalure' and has been found effective in attracting male houseflies.

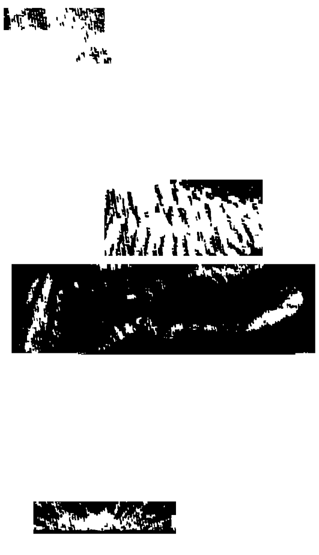
Feeding in the housefly

A FLY MAY encounter a food source purely by chance or may locate it from attraction by form, colour, odour, etc. In either case, whether the fly will eat the food or reject it depends on a lot of other things.

Take the feeding organ, for example. This is a long, slender, extensible structure called proboscis (Fig. 6) (so called because it resembles the trunk of an elephant). The free tip of the proboscis is called labellum which consists of a pair of lobes. The surface of these lobes is traversed by a system of fine channels called pseudotrachea leading into a common passage which is connected with the food canal of the fly through its proboscis.

Normally, a fly keeps its proboscis retracted and folded. But at feeding time, it extends its proboscis, everts the lobes of the labellum and lets them touch the food (Fig. 9). If the food is liquid, it is lapped up like a sponge by the pseudotrachea — hence the epithet ' sponge on wings '. If the food is solid, the fly throws up saliva which dissolves the soluble components, if any, in the food source, which is then ingested. Yes, the fly takes in food always in the liquid state.

Fig. 6 No exotic flower but an enlarged lateral view of the head of a housefly. P — Proboscis, L — Labellum. The greater part of a fly's head is taken up by its eyes, which are compound organs made up of thousands of six-sided facets — each a complete eye in itself, and the total picture seen by the fly is a composite of what is seen by the individual facets



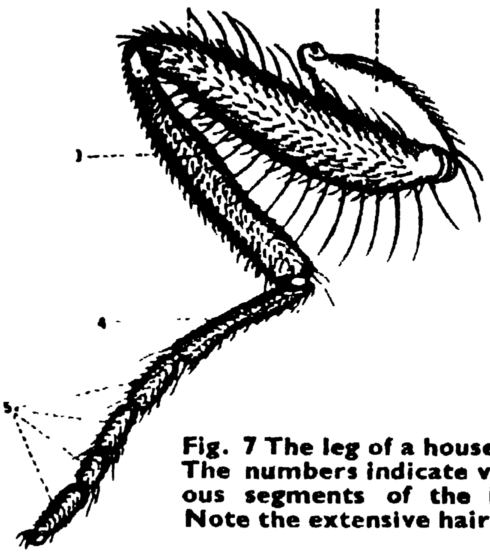


Fig. 7 The leg of a housefly. The numbers indicate various segments of the leg. Note the extensive hairs

BUT WHETHER or not the food will be eaten depends on its taste. If the taste is acceptable, the proboscis is extended. If the taste is unacceptable, the proboscis remains retracted, or, if already extended, it is withdrawn and there's no more feeding. In general, substances which are likely to be eaten by the flies are those which taste sweet to man, e g sugars. In addition, milk, other proteins and water are also highly acceptable items. On the other hand, salts, acids, etc are unacceptable because they inhibit feeding response. This behavioural criterion of proboscis extension (Fig. 9) — that it is extended only when the food is acceptable — can be used to determine the extent and type of stimulatory capacity of various substances for the flies.

Another method of comparing the acceptability of various substances is to measure their intake by the flies as was done for various sugars in an experiment using J-shaped potometers (Fig. 8). Five per cent solutions of the sugars fructose, glucose, sucrose and maltose were ingested by houseflies in 24 hours in much greater volumes because of a higher taste-stimulating capacity than the sugars lactose, arabinose and xylose. Certain other sugars, e g sorbose and inositol, inhibited feeding. Responses of the flies to mixtures of acceptable and unacceptable substances, e g a sugar and a salt, depend on the relative proportions of the ingredients. Thus, the stimulation by a high concentration of sugar in a salt-sugar mixture may cancel out the inhibition induced by salt and permit proboscis extension and even actual feeding. On the other hand, if the salt concentration of a salt-sugar mixture is very high, even a starving fly may fail to feed on it.

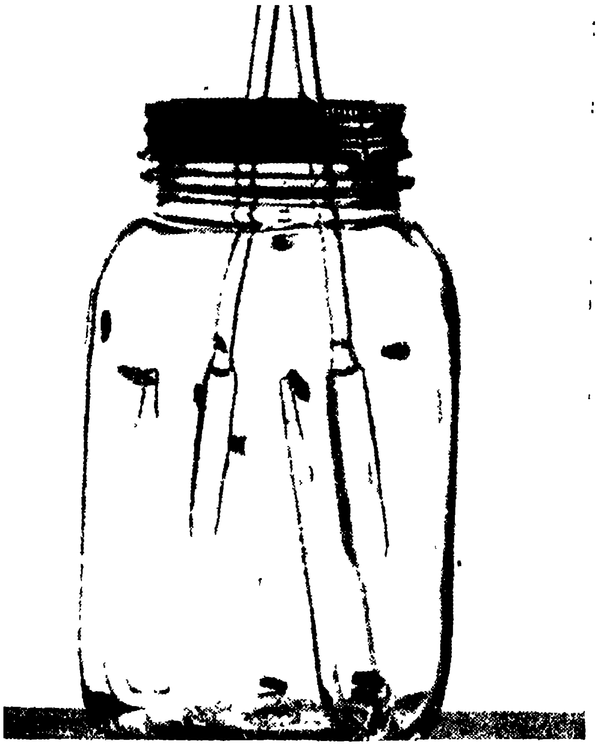


Fig. 8 Measuring food-intake of flies. The J-shaped glass tubes are each filled with marked volumes of different solutions whose levels continue to decrease as the flies go on feeding

THIS DISCRIMINATION by the fly between the tastes of different substances is made possible by several fine hairs present on the fly's feet (Fig. 7) and labellum which are similar in function to the taste papillae on our tongues. Intensive research by Professor Dethier has given a comprehensive insight into this discrimination mechanism in a blowfly. Much of the information given by Dethier for the blowfly also holds good for the housefly, as observed by other investigators. In fact, there is enough documentation to lay bare the intimate architecture of these minute sensors.

The whole system is one of amazing finesse. It has been shown that each taste hair is provided with five sensory nerve cells. Each of these sends a nervous extension called dendrite from its one end and a long nerve fibre called axon from the other. The axons are finally connected with the central nervous system including the brain. On the other hand, the dendrites serve as recipients of information from the outer world, which is transmitted through the receptor cells and the axons to the central nervous system of the fly.

The dendrite from one of the five receptor cells terminates at the base of the taste hair. This cell is a mechanoreceptor. It is stimulated by mechanical stimuli, for example, when the hair comes in contact with a surface. The dendrites of the remaining four receptor cells extend through the hair to terminate at a minute pore at its tip. These cells are chemoreceptors — they are stimulated when the hair comes in contact with certain chemicals. It has been shown by using elegant electrophysiological techniques that one of the four chemoreceptors is stimulated by water, another by sugar, and the third by salts, acids, etc. What the fourth does is as yet uncertain, though it is suspected that it may be a protein detector.

When a particular receptor is stimulated by an adequate amount of the right substance, it sends on nerve impulses through the axon to the central nervous system. The latter then sends out another set of what are called motor nerve impulses to the various muscles controlling extension/retraction of the fly's proboscis. It is now known that stimulation of the water and sugar receptors results in the extension of proboscis and feeding. On the other hand, stimulation of the salt receptors causes withdrawal of the proboscis and prevents feeding. Substances such as acids and alcohols put the sugar and water receptors temporarily out of commission, thereby suppressing feeding activity.

Tasting with legs

WE ARE NOW IN a position to trace the whole feeding sequence. The housefly is able to discriminate between acceptable substances such as sugars and proteins and unacceptable ones such as salts, acids and alcohols by *merely walking over them!* It tastes with its legs. As soon as the tarsi or ' feet ' of a fly come into contact with a possible food source, nerve impulses are triggered for onward transmission to the central nervous system. If the food is acceptable, the impulses are stimulatory; they induce the central nervous system to send ' directives ' or ' commands ' (motor nerve impulses) to the muscles controlling the proboscis, and the proboscis is extended. But, even now, the food material must first be okayed by the taste hairs on the labellum, which are similar to but more sensitive than those on the feet. It is only when both tarsal and labellar chemoreceptors have been adequately stimulated that the labellar lobes evert and ' lapping ' up or actual feeding begins.

We have seen that initiation of feeding is primarily the outcome of stimulation of the fly's

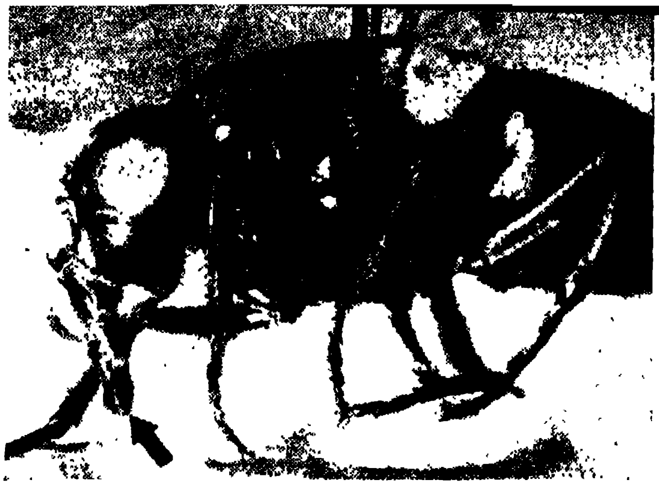


Fig. 9 Tasting with legs. Note the proboscis being extended (arrow) as the feet of the fly are made to touch a stimulating (sugar) solution kept in a petri dish

chemoreceptors. But how does a fly know when to stop feeding? In higher animals, including man, there are various controls governing the food intake. In the flies, as we have seen, elaborate, semi-autonomous systems of control regulate every aspect of their life and behaviour. Termination of feeding in flies is brought about by signals from what are known as stretch receptors in certain regions of the alimentary canal.

As the name implies, these sensors detect mechanical changes such as passage of food and distension of the alimentary canal. Most important are some receptors in an anterior part of the food tube, called the foregut; their messages are carried by a nerve, called the recurrent nerve, to the nervous system. Again, there are receptors in the body wall which signal the state of distension of the fly alimentary canal to its nervous system through ventral nerves. Messages from these centres invoke commands from the nervous system to withdraw — or, retract the proboscis — thereby terminating feeding.

The fly may be considered primitive in that the two functions, initiation and termination of feeding are controlled by two disparate systems. Sometimes this leads to certain very anomalous situations. As for example when the recurrent/ventral nerves of the fly are surgically cut. Such surgically operated experimental flies can be made to feed *ad libitum* on a continually stimulatory substance — so much so that the fly swells up to unbelievable dimensions. But still it goes on feeding since its nervous system does not receive any messages from the sensors in the foregut and the body wall (as the nervous trunk routes carrying these messages are cut). Incredible as it may appear, such an experimental fly goes on feeding until it bursts, literally, and dies.

Mating and reproduction

DURING THE FIRST 2 to 3 days of its adult life, the fly is an avid gourmet. After this, it begins to divide its attention equally between the search for food and the hunt for a mate. Until recently, it was not known how the male sought out the female. As we have mentioned, however, Carlson and his colleagues have recently announced the discovery of a substance (Z-9-tricosene) which the females emit. The males are enticed towards the females by this chemical which is a sex pheromone. Though initial contact between a male and a female may take place in the air, mating usually takes place on some substratum, with the male astride the female in a characteristic posture.

Female houseflies are said to be monocoitic, ie they mate only once. It has been shown recently that this unusual chastity is forced on the female flies by a chemical substance produced by the males' accessory reproductive glands; the chemical is deposited in the female

Larvae : Disease and Curative Agents

Accidental entry of living maggots into body tissues results in a severe condition called myiasis in which the host tissues are destroyed, followed by septimacea, oedema and other ill effects. Natural apertures of the body, and wounds, sores, etc are common sites for such entry. Though myiasis is usually caused by larvae of flies other than *Musca domestica*, cases are on record for this species also.

Housefly larvae, however, have a better reputation as wound-healers. The practice of using maggots for wound therapy (especially prevention of septimacea) was extensively followed during World War I. With the discovery of the chemicals allantoin and urea, which the larvae secrete and which are actually responsible for the healing effects, housefly maggots are no longer used in modern medical practice, though in some backward, remote areas of the world, maggot therapy may still be practised.

during copulation. Studies are going on to unravel the chemical identity of this inhibiting chemical (it has been shown to be a polar material of low molecular weight). The one and only seminal impregnation is apparently sufficient for production of approximately 5 to 20 batches of 75 to 150 eggs which a female housefly lays at various intervals during its life. An interesting feature of fly reproduction is the essential requirement of protein (from milk or any other source) for egg production. A female, even though successfully impregnated, will not produce eggs if fed on sugar alone, although it may live out nearly its whole life-span.

New dimensions of fly control

THE TRADITIONAL fly control measures like good sanitation, covering and prompt disposal of refuse or waste bins, heaps and manure, screening of windows, doors, etc also included the use of conventional insecticides such as DDT, BHC, Dieldrin, Malathion, Diazinon and Dichlorovos. However, the houseflies develop resistance to many of these insecticides. Besides, they are toxic chemicals and pose both short- and long-term hazards including environmental pollution. This has led to attempts to seek other methods of control. One of the alternatives is to manipulate the fly behaviour itself.

We have already described how the housefly has a repertoire of built-in responses, programmed to act on appropriate signals. These signals again, we have seen, are on the one hand natural stimuli like form, colour, smell, etc, coming from various objects; on the other, they are highly specific and complex chemicals — the pheromones — specially produced by the insects themselves to serve as means of communication between them. If we can manipulate these various stimuli judiciously, e g by misplacing them in time or space, we may influence the behaviour of the pest species so as to hasten its own destruction. Thus, the knowledge that flies prefer rough and dark surfaces, projections and edges can guide us in limiting the application of the insecticides to such surfaces rather than spreading them all over.

Again knowledge of the flies' colour and light preferences has in fact been used to rig up traps that use fluorescent lamps emitting blue-violet or ultra-violet light to attract flies which are trapped and electrocuted in electric grids.

The use of various fly attractants mentioned earlier in traps and baits or for luring them to aggregate in chosen areas where they could be destroyed, are other ways of fly control by behavioural manipulation. In this field, the synthesis of ' Muscalure ', the fly sex pheromone, promises fair dividends. Likewise, once the male accessory gland substance which inhibits the female from copulating is identified and synthesised, it could open distinct possibilities of selective fly control without using insecticides. The search also goes on for newer and better attractive chemicals/colours/sounds/electromagnetic energy and other novel stimuli which may hoax the flies into spelling their own doom.

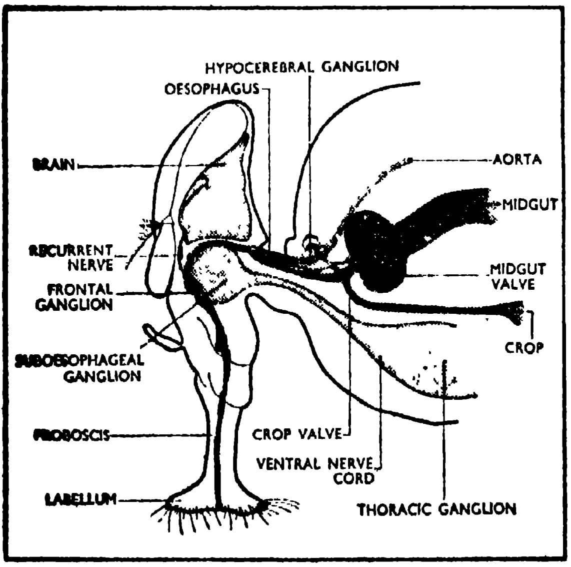


Fig. 10 Diagrammatic sketch of fly physiology

A disease-carrier

NUMEROUS short and long hair or bristles called cheate or seate cover the fly body in a definite pattern. When a fly visits waste heaps, manure, etc, disease germs are transferred to the hair on the legs, body and the mouthparts. Many germs are ingested along with the ' food ' the fly is taking in. When the fly next alights on food or drink meant for human consumption, the disease germs picked up from various sources are passed on to the eatables. The flies thus act as vigorous mechanical carriers of disease germs and may cause serious epidemics or aggravate and spread mild, sporadic infections. Examination of fly extracts, excreta or vomit or even the surface on which a fly has crawled can reveal the kind of germs the fly can transmit. It has been estimated that some 100 different species of pathogenic organisms, causing some 65 different diseases of man and animals can be transmitted by houseflies. Among the more serious human maladies may be listed dysentery, typhoid, cholera, leprosy, tuberculosis, poliomyelitis, infective hepatitis, yaw, trachoma, conjuctivitis and parasitic worms.

Recently, however, questions have been raised about the seriousness of the fly's role as a vector of various diseases. Most diseases are caused by the introduction of very large numbers of germs. For example, at least 100,000 viruses of poliomyelitis need to be introduced to cause the disease. Or, a million or more Salmonella bacteria must enter the body to cause salmonellosis — a kind of food poisoning. In other words, there is a threshold level for every infection. Generally, this is very high in terms of the numbers of organisms required to produce the actual infection. It is obvious that a single fly cannot transmit anything akin to these numbers of pathogenic organisms by its legs or body alone. In so far as transmission through fly ' vomit ' or excrement is concerned, it has been found that although millions of bacteria may be present in the food of the flies, these are totally destroyed in a certain region of the food tube of the fly called the midgut. The fly midgut (approximate middle region of the food tube) has, in fact, been called the ' valley of death ' for bacteria since it is very highly acidic (pH 3·0-3·5). Food ingested by the fly takes only about 30 minutes to pass through its entire food tube. During this journey, the sojourn of the ingested food in the midgut is only for about 5 minutes. This short period of time is, however, sufficient to destroy almost completely the bacterial population of the ingested material. The nature of the midgut acid is not known but is suspected to be either a hydrogen or phosphate containing chloride. Thus, fly vomit or excrement, which might have been suspected of having the potentiality of transmitting the extremely high numbers of pathogenic organisms required to produce a disease, cannot be incriminated any more.

However, it must not be forgotten that while a fly may not transmit a disease directly or at once, the probability of an explosive build-up by rapid multiplication of even a few pathogenic organisms deposited on food or drink is very strong. This is especially true of the more tropical climates. In India, for instance, the extremely high incidence of trachoma, particularly in the rural areas with their generally primitive sanitation and excessive flies, may well be correlated, though there has been no actual demonstration so far. Again, the repeated incidence of dysentery and diarrhoea as epidemics in times and areas where sanitation deteriorated and flies multiplied fast and excessively, cannot be ignored. Perhaps the situation can be best summed up by stating that bad sanitation/hygiene contribute to the greater probability of houseflies spreading various infections.

To an extent, a major handicap of many, if not all, synthetic fly attractants known till now has been their noxious smell, which means they cannot be used in and around human habitations. To overcome this lacuna, the authors have been testing certain naturally occurring compounds with pleasant smells for their effects on both the development and behaviour of various insects (see 'Enticing Insects to Doom', *Round-up of Research*, SCIENCE TODAY, June 1973). In our work on houseflies (presently under publication), we have found a few such compounds showing promise in laboratory demonstrations. The ideal is to have such agreeable and non-hazardous compounds, with both behavioural and developmental effects, for pest control. They should preferably be naturally occurring — presumably that would make them biodegradable, i e not affecting the environment. They would be especially useful for management of populations of synanthropic vector species (i e a disease-carrying species cohabiting with mankind) in houses and around human settlements. That is the future shape of things to come in the field of vector control and pest management.

Dr. Saxena, FNA, is Professor of Zoology at the University of Delhi, where he and his team are working on various aspects of insect physiology, behaviour and computer-based simulation models. He has worked in various laboratories abroad.

Dr. Sharma is research associate in the Departmen of Zoology, Delhi University. He has worked on insecticide resistance in insects and is currently working with Prof. Saxena on problems of insect behaviour and pest control/management by non-insecticidal methods.

round-up of research

GENETICS

The Blank X Chromosome in Women

THE first direct demonstration of X chromosome inactivation in humans, comparable to that in other mammals, is contained in a report in *Nature New Biology* (*245*, 58, 12 September 1973) by Drs. E. Passarge and E. Fries belonging to the Institut fur Humengenetik, Hamburg, Germany.

It is a well established fact that each human cell contains a total of 46 chromosomes of which 44 are autosomes and 2 sex (X and Y) chromosomes. Males inherit a Y chromosome from the father and an X from the mother, whereas females inherit one X chromosome from the father and one from the mother. Thus each male cell contains one X and one Y chromosome, whereas a female cell contains two X chromosomes. A major role in genetics is played by the X chromosomes since in addition to determining sex, they carry information relating to colour vision, haemophilia and many other body functions. On the other hand, the Y chromosomes carry solely information for sex determination.

In 1961, Dr. M. F. Lyon of England put forward a theory that one of each pair of X chromosomes may become genetically inert or inactivated early in the life of a female foetus. This inactivation is irreversible, and, hence, when the embryo grows and the cells divide, each daughter cell will contain one inactivated X chromosome.

The theory of Dr. Lyon was based on extensive work on female mice heterozygous (carrying two unlike alleles—one of the alternative forms of a gene—at a particular site on each chromosome) for X-linked colour genes. When the alleles are the same, as in a homozygous mammal, the colour of the coat may be, say, black or yellow. When they are different, the mammal will have an intermediate brown as coat colour, since each skin cell would contain genes for both black and for yellow coat colour. But according to the theory, one of the X chromosomes may be inactivated at random in each cell. In this case, each individual cell has just one active gene for either black or yellow coat, and the coat will have intermingled patches of black and yellow. Further support for the theory of X-inactivation has come from experiments with other mammals and studies of X-linked human genes expressed in cultured cells in the laboratory. The theory has, however, never been tested before in humans *in vivo*.

Drs. Passarge and Fries have now tested the theory on seven females, each of whom had at least a son affected with the X chromosome linked disease hypohidrotic ectodermal dysplasia. The affected individuals cannot sweat normally, because of the absence of sweat glands and pores, and the external skin tissues, especially at ridges of fingertips and palms, are abnormal in them. The mothers were clinically normal, but were by necessity expected to be heterozygotes for the disease, since their sons' X chromosomes came from them.

The German scientists on examination of the skin at the mother's fingertips found a patchy mosaic distribution of areas either lacking sweat pores as in the affected sons, or areas showing normal sweat pores as in normal individuals. The mean number of sweat pores per cm dermal ridge was 9·4 in the seven heterozygotes, 24·1 in six control females and zero in the ten sons. One woman had two entirely normal fingertips and one nearly lacking all sweat pores. They have thus demonstrated that X chromosome inactivation does occur in humans.

ENTOMOLOGY

How Flashing Fireflies Mate

ASIAN fireflies emit light synchronously and this behaviour has attracted the attention of Western naturalists for more than a century. The relation of the synchronous flashing to the mating behaviour has long been a puzzle to entomologists. Previous explanations have concentrated on mating as a swarm, and have neglected consideration of individual fireflies within the swarms in the courtship procedure.

Dr. J. E. Lloyd of the Department of Entomology and Nemätology, University of Florida, USA, now suggest that individual fireflies are indeed involved and follow a well-defined mating protocol. His suggestion is based on studies he conducted in Melanesia on eight species of *Pteroptyx*, the synchronising fireflies, and 15 species of *Luciola*, a related genus. By combining the results of his study with observations of other workers on 96 species of other firefly genera, he has constructed a model for the mating behaviour of fireflies. The details of the model are published in *Nature* (*245*, 268, 5 October 1973).

His model may be briefly summarised as follows. Fireflies of both sexes are initially attracted to the flash rhythm of the males of their species, and congregate in swarm trees that already harbour members of their species. The males in the trees detect the approaching females by their light, and modify their luminiscent behaviour to enhance the attractiveness of their own position on the tree, and thereby stimulate females to land near them. When the males land on the tree, they flash in synchrony with nearby males, to increase the likelihood of obtaining females. The females, on the other hand, land near and observe specific males. Once they have entered the swarm and landed, other behaviour than flashing brings individual males and females still closer. Dr. Lloyd believes that in the terminal stages of courtship the pair in close proximity ceases to flash and copulation takes place thereafter.

Both the sexes congregate in swarm trees, because such sites will contain concentrations of sexually competent males and females and the likelihood of finding a mate is greater. A perched male synchronises his flashing with his neighbours since this enhances the brightness of his locus on the tree. The luminiscent performance of a male is of prime importance in his competition with other males for selection by a female. Dr. Lloyd concludes that behaviour other than flashing brings individual males and females close together after they enter the swarm, since he has observed perched males of a certain species flicker in response to glows of females that fly over them. These females sometimes turn, swoop low over responding males and then land within a few cm of them.

Experimentally, the Florida entomologist was able to make male fireflies of four *Pteroptyx* species flash in synchrony and approach to within a few cm of a penlight. He had also observed one male firefly perch close to another already flashing with a female, and oust it by flashing in synchrony with her sooter.

He concludes from his studies that the mating behaviour of *Pteroptyx* fireflies is no exception to the natural selection theory, as formulated and developed over the past century.

PARTICLE PHYSICS

Evidence for Neutral Weak Current

AFTER virtually striking a gold mine for a period of nearly two decades, there has recently been a lull in the spate of discoveries in fundamental particle physics. The work of a few scientists in isolated laboratories throughout the world in the 1950s has now given place to collaborative experiments involving teams of scientists from different nations, in order to produce worthwhile results. This, in fact, represents international scientific collaboration at its best. The new strategy is beginning to pay dividends, for a galaxy of 55 physicists from seven European laboratories — Aachen (Germany), Brussels (Belgium), CERN, Geneva (Switzerland), Paris (France), Milano (Italy), Orsay (France) and London (England) has now announced the probable discovery of neutral currents in weak interactions in *Physics Letters* (*46B*, 138, 3 September 1973).

The elementary particles so far discovered have been classified on the basis of their properties into photons, leptons and hadrons. The type of interactions in which they participate have also been classified into three broad categories, viz strong, electromagnetic and weak (see Science Today, p. 13, February 1970). The weak interactions which are a million million times weaker than the electromagnetic interactions have properties similar to the latter at the most fundamental level. For example, theoretically both these interactions are described in terms of currents, a concept remotely related to the everyday electric current of the macroscopic world.

The theory of quantum electrodynamics allows exact calculations to be made for electromagnetic processes, but the calculations of weak processes, because of imperfections in the theory, have so far been crude. Since the beginning of last year, a family of new theories attempting to explain the weak interactions more fully has appeared in some leading physics journals. These theories, of Dr. S. Weinberg and others, predict one or two physically observable phenomena like neutral current or a new type of heavy lepton (a massive electron or muon).

The collaborative experiment now reported consisted in exposing the giant heavy liquid bubble chamber named 'Gargamelle' at CERN (Centre European Researche Nucleare) to a neutrino and to an antineutrino beam. The neutrinos and antineutrinos take part only in weak interactions. The neutrinos on striking a nucleus give rise to two types of reactions. In the first, known as the 'charged current' (CC) interaction, the products of the reaction always include a charged muon in the final state, along with strongly interacting hadrons. In the second, known as the 'neutral current' (NC) interaction, predicted by the new theories, no charged muons will be emitted in the reactions.

The scientists, on analysing about 290,000 bubble chamber pictures of neutrino interactions, observed 166 events which behaved as expected if they arise from neutral current (NC) induced processes. Hadrons, but no muons or electrons, were observed in these events; 756 charged current events were also seen in the same pictures, and the distribution along the beam direction of NC events had the same shape as CC. They investigated a number of background processes, the most important of them being neutral hadrons produced by neutrino interactions in the shielding of the chamber, but none could reproduce the observed distribution of the NC events either qualitatively or quantitatively.

The European team, hence, concludes that they have observed either neutral current induced reactions or heavy leptons decaying mainly into hadrons. Whatever be the final interpretation, their results have produced considerable excitement among particle physicists.

ASTROCHEMISTRY

More About Molecules in Space

THE discovery of organic molecules in interstellar space has given some credibility to the speculations that life, presumably like ours, may exist in other parts of our Galaxy. The first two molecules—ammonia and water—were discovered by radio astronomers in the United States, nearly five years ago. Before that, the only materials in space known to emit radio signals of a well-defined wavelength were hydrogen gas and the hydroxyl molecule.

The use of radiotelescopes capable of detecting radiation in the microwave region has, since then, enabled astronomers to discover nearly 21 molecules in space including such complex ones as methanol, formic acid and formaldehyde.

Dr. C. A. Gottlieb and Dr. J. Ball of the Harvard College Observatory have now announced in *Astrophysical Journal Letters* (*184*, 59, 1 September 1973) the discovery of the twenty-second molecule, namely, sulphur monoxide in the direction of the constellation Orion where several other molecules have been discovered before. They have confirmed their observation by showing that sulphur monoxide is present not just in Orion but also in at least six other sites in our galaxy. The latest discovery adds up the number of interstellar molecules known to contain sulphur to five.

The presence of organic compounds in the cool regions of the interstellar space, containing clouds of gas and dust, has also interested astronomers in another respect, since they believe that these regions may be the birth place of stars. However, what has been puzzling them is how these molecules form and survive in the harsh environments of the interstellar space. The question of the formation of these molecules has created interest in astrochemists and Drs. A. Dalgarno, M. Oppenheimer and R. S. Black, also of the Harvard College Observatory, USA, have in *Nature Physical Science* (15 October 1973) sketched some of the pathways by which the simpler molecules can be synthesised into the complex formaldehyde (HCHO).

In the diffuse interstellar clouds, according to the American scientists, formaldehyde, one of the most widely distributed and abundant molecules in the galaxy, is more likely to be formed from the reaction $CH_3 + O \rightarrow H_2CO + H$. The CH_3 is built up in three stages. Initially, photoionisation of carbon by starlight gives C^+. This then combines with a molecule of hydrogen to form CH_2^+. The CH_2^+ on combining with another molecule of hydrogen gives $CH_3^+ + H$. Another mechanism of formaldehyde formation is the reaction $CH_3^+ + O \rightarrow H_2CO^+ + H$; the H_2CO^+ ion then loses its positive charge through exchange with heavy elements to leave formaldehyde. Formaldehyde itself is subject to destruction by photoionisation, but Drs. Dalgarno, Oppenheimer and Black show that for a wide range of densities and ultraviolet fluxes, the formation rate exceeds the destruction rate.

K. A. Neelakantan

. . . and new processes

Chrome-tanning Takes a Cue

THE new process for improving the wet-heat resistance of leather during chrome-tanning, developed at the Central Leather Research Institute, Madras, should put leather on a par with wool and cotton textiles in looks, besides affording several advantages to the manufacturer. Thanks to this process, the leather can now withstand shrinkage when placed in very hot water during dyeing.

Tanning is the process by which impurities present in raw hide are removed and the hide brought into a condition in which it can resist bacterial, thermal, chemical and other influences. "Chrome-tanning" is performed in drums in which the pelt is revolved at low speed along with the tan liquor, containing a chromium salt.

Chrome-tanned leather has replaced leather tanned by the conventional tanning processes like vegetable or alum tanning. Apart from shoe uppers, even light leathers such as suedes, garments, gloves, and linings are nowadays made of chrome-tanned leather. Some of the reasons for the popularity of chrome-tanning are : chrome-tanning is quick, and chrome-leather absorbs less water, has a fairly high resistance to wet heat and can be exposed to boiling water for a short time. Chrome-leathers can also be easily dyed with the latest standard modern dyes.

But chrome-leather has one drawback : it will shrink within 20 to 25 minutes of being placed in boiling water. This has imposed restrictions on the temperature to be maintained in post-tanning operations like dyeing, and lubrication with emulsified oil products. At present, the temperature of the dye bath is not raised above 60°C. As a result, leathers will not take bright and fast shades as textiles do.

To overcome this limitation, a product, " ladder link ", was developed at the Institute. " Ladder link " is a poly-functional agent capable of introducing ladder-type cross-links in between two chrome atoms fixed to the skin protein. By treating skins with this product during chrome-tanning, the wet-heat resistance of leathers is greatly enhanced. The wet leathers thus treated, or their crusts (chrome-leathers dried after lubricating with oil products are called crusts), don't shrink in boiling water for about two hours.

This is a major improvement in the technology of chrome-tanning — perhaps the first since the commercialisation of chrome-tanning — and will place leather on a par with wool and cotton textiles. This may make it even superior, because (1) the treatment enables the leather manufacturer to adopt the " hytherm " process of dyeing used in textile manufacture for obtaining bright fast shades; (2) leather as clothing material has better toughness and strength; and (3) leathers, like textiles, can safely be exposed to the steam after screen printing for fixing the print, and they will not shrink even after prolonged exposure to steam.

The improved product can be used in making a softer type of blazed kid, uppers and upholstery. These are currently in great demand. Soft leathers marketed at present lack tightness of grain. But the ladder link used in chrome-tanning not only takes care of that, but also makes the leather full, soft and round in feel.

Hitherto, to obtain semi-chrome tanned diaphragm leather (used in gas meters) which would not shrink when placed in boiling water for 30 minutes, East India tanned leather was repeatedly tanned to incorporate " chrome " into leather. Now by incorporating " ladder link " at the appropriate stage of chrome-tanning, semi-chrome diaphragm leathers can be made using less chrome. The treatment was also found to be beneficial in making various types of semi-chrome leather.

Chrome-tanning of hides and skins and production of finished leathers, at present, are mainly confined to the Bombay, Madras, Calcutta and Kanpur regions. Finished leathers, specially light leathers such as suedes and garments, are not much exported. But the new product/process should now help the leather manufacturer to increase the production of quality leather for sale abroad as well as for indigenous consumption. The know-how is now available for commercial exploitation through the National Research and Development Corporation, New Delhi.

K. J. Kedlaya

Dr. Kedlaya is a scientist working with the Central Leather Research Institute, Adyar, Madras.

NOBEL PRIZE 1973

CHEMISTRY

OR, rather, it is the "chemistry for chemists" that has brought Dr. Ernst Otto Fischer, 55, of Munich University, and Dr. Geoffrey Wilkinson, 52, of the Imperial College of London, this year's Nobel Prize (half of $120,000 for each). Their independent work in the field of organometallic chemistry has been specifically on the "sandwich" molecules — where two symmetrical hydrocarbon rings make a sandwich around a metal — like ferrocene, the first sandwich molecule to be discovered (in 1951, with Wilkinson in the research) in which iron is sandwiched by two symmetrical carbon atoms. X-ray crystallography by Fischer and infra-red spectroscopy by Wilkinson established the true structure of ferrocene.

Their work has opened up a completely new chemistry — transition metal organic chemistry and ferrocene has now been followed up by several other transition metal organometallic compounds containing nickel, cobalt and other metals.

The future holds several bright promises. For example, the anti-knock tetraethyl lead in gasolene may be replaced by less dangerous metallic ingredients — something that would make the anti-pollutionists happy.

Incidentally, this year's award continues the dominance of UK and Germany in chemistry. Of the 85 chemistry prizes given since 1901, Germany has won 23, UK 19 and the USA 19. Together these three countries have taken away 72 per cent of the awards.

Fischer

Wilkinson

Giaevar

Josephson

PHYSICS

THERE are three joint winners in physics this year. Dr. Leo Esaki, 48, a Japanese citizen now working with IBM's research centre at Yorktown Heights, NY, and Dr. Ivar Giaevar, 44, Norwegian born and an American citizen now, working with General Electric's laboratories at Schenectady, NY, have won the award "for their experimental discoveries regarding tunnelling phenomena in semiconductors and superconductors, respectively". The third winner, Cambridge (UK) University's Dr. Brian D. Josephson — at 33 one of the youngest Nobel Laureates ever — is cited "for his theoretical predictions of the properties of a supercurrent through a tunnel barrier, in particular those phenomena which are generally known as Josephson Effects".

What is the tunnelling phenomenon? It is the passage of particles *through* potential barriers, instead of over them. A potential barrier is a kind of energy fence — a space in which forces are so balanced that an incoming particle is thrown back unless it has enough energy to sail over. That's what classical physics said. Later, quantum mechanics showed that a particle could get across with *less* energy by "tunnelling". And this year's three winners worked on tunnelling junctions in electronic circuitry where potential barriers result from the insertion of an insulating layer between two conductors.

Esaki worked with germanium. He found that by making the semiconductor very thin and doping it heavily with impurities, he could get a tunnelling current. This led to the invention of the Esaki Tunnel Diode which has a polarity reversed from other diodes and contains a negative resistance region in which an increase in voltage causes the current to fall rather than rise.

Giaevar worked with junctions in which one metal electrode was superconducting and the other was not, and showed that the way the current changes with voltage depends on the density of electron energy states in the superconductor.

Brian Josephson predicted in 1962 (he was only 22 then) a new kind of tunnelling between two superconductors — the tunnelling electrons would go in pairs (the so-called Cooper pairs) and not as single electrons. Already confirmed experimentally, the Josephson Effect has many interesting applications, including measurement of magnetic fields of the order of 10^{-9} gauss, voltages less than 10^{-18} volts, etc. It is now extensively used as radiation detectors from the Sun and other stars, and also microwave generators. It has also found many applications in the electronics industry.

Born in Osaka, Esaki took his PhD from Tokyo University in 1959 and went to the USA in 1960. Giaevar was born in Bergen, Norway, studied at the Norwegian Institute of Technology at Trondheim, emigrated to Canada in 1954 and to the USA in 1956. They both will get half of the $122,000 prize; the other half will go to Josephson, a native of Wales, who studied at Cambridge and is still working there.

PHYSIOLOGY & MEDICINE

IS ethology — the comparative study of animal behaviour — a medical field? Most practitioners and teachers of medicine would say, no, as many did after this year's $112,834 award went to three pioneers in this field — Karl Von Frisch, 87, now living in retirement in Munich, West Germany, Konrad Zacharias Lorenz, 70, a Viennese Austrian now with the Institute of Behavioural Research in Gruenan, Austria, and Nicolas Timbergen, 66, Dutch born, now at Oxford University. The Nobel Committee has given its reason: though "their first discoveries were made on insects, fishes and birds, the basic principles have proved to be applicable also on mammals, including man".

Frisch was the discoverer of the bee-dance — the communication signal (besides the odour of nectar pollen) by which a bee that has found a food source tells the others about its location. He showed when the dance is circular — alternating clockwise and anti-clockwise circles — the food is within 75 metres of the hive; on the other hand, the (stomach) wagging dance indicates a longer distance. Frisch also showed that the dance slowed down with the fall in food supply. And each subspecies has its unique dance that no other subspecies can interpret. That means, the dance is inborn and not learned.

Lorenz started his work with geese at the Max Planck Institute of Behavioural Physiology to show that animals are born with innate patterns of behaviour known as "imprinting." For instance, geese are imprinted to follow the first moving object they see after hatching. Normally it is the mother, but Lorenz showed other moving objects, including inanimate ones, would do. From geese, Lorenz moved on to other birds which led other researchers to study how far experimental conditions like isolation or overcrowding produce psychotic behaviour in young primates. Many of the results have important bearings in psychiatry. Lorenz's latest work was an extension of the innate behaviour theory to humans and in 1963 he published *On Aggression*, a controversial book in which he argued that aggression is imprinted into human beings similar to the imprinting of instinctual behaviour in lower animals.

Esaki

Frisch

Timbergen

Lorenz

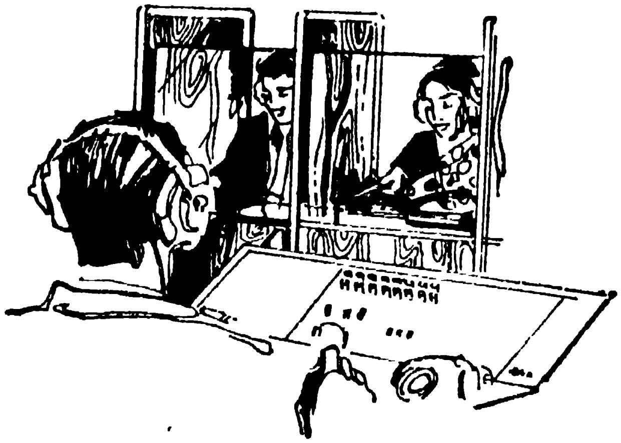
Leontief

Timbergen has been the torch-bearer for both Frisch and Lorenz, testing and proving their theories as well as his own. As a child he hated insects, yet later on did a series of studies on how homing wasps find their way. His subsequent work with seagulls confirmed much of Lorenz's instinctive behaviour theory. But Timbergen went on to show that learned behaviour was as important as the instinctive, like the bird Oyster Catcher which will instinctively peck at anything, but learns to peck only at oysters and shellfish by watching the mother bird. His recent work extends to man: while animals, he says, do not like to kill their own kind, especially when the victim shows facial expressions of appeasement, man can kill without feelings because long-range weapons preclude his coming face to face with the victim.

ECONOMICS

E is the father of the input-output tables which, he himself says, has brought to economics "a 200-inch telescope". This year, Wassily W. Leontief, became the fifth economist to win the Nobel Memorial Prize in Economic Science (it was started in 1969). Russian-born Leontief was at Harvard University when his famous paper appeared in 1936. He is still with Harvard.

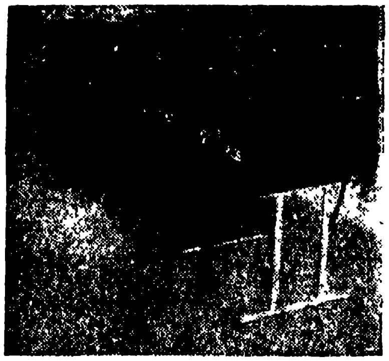
The input-output analysis treats the economy of a country as a single system in which all parts are interrelated. Inputs and outputs are charted as numbers in columns and rows in a grid. Today the Leontief matrix is used all over the world, mainly by economic planners and market analysts, particularly to construct models to project the future structure of the economy as a result of growth.



ELECTRONIC LANGUAGE LABORATORY

In the days of Gurukula system of learning, the Vedas and Puranas were taught by word of mouth, and as such the purity of intonation and rhythm were handed down from generation to generation. But with the advent of greater intermingling among nations and the emergence of the multilingual society, the methods of teaching have also undergone revolutionary changes. To learn a foreign language, or even one of our regional languages, may not be very difficult. But to speak the language 'like a native' is a different kettle of fish. It requires incessant practice and expert coaching. This is where the BEL-developed Language Laboratory system becomes invaluable.

Developed by BEL, in cosultation with the National Council of Educational Research and Training, Delhi, the Language Laboratory, an audio-teaching aid, can be used in various class-room configurations. The Laboratory consists of a master console and a number of independent booths, each equipped with a tape recorder, head phones and a microphone. The students sitting in the booths can, by the aid of the teacher at the master console, repeatedly record and play back the language being taught; and by such controlled practice, obtain optimum proficiency.



The students in the booths will be using high sensitivity microphones and highly padded earphones, and will not disturb each other.

The teacher from the master control can unobtrusively listen in to monitor, or break in to correct any student. He can also communicate individually or collectively with the students. These are only some of the salient features that highlight the versatility of this system. In fact, the system can be adapted to any kind of instructional programme.

The successful indigenous development and application of the BEL Language Laboratory is just one more among many examples which demonstrate that the nation has arrived at the age of sophisticated electronic systems.

This Language Laboratory system is only part of the BEL family of electronic systems. In defence, entertainment, industry and weather forecasting, BEL's continuing design and development programmes are keeping pace with the fast changing technology in electronics. The result is comprehensive systems capability in electronics, to meet the challenges of tomorrow.

BEL
now give India complete electronic systems capability

BEL BHARAT ELECTRONICS LTD.

AIYARS-BEL-[illegible]

blurs & bright spots

The Good Samaritan had plenty of time!

REMEMBER that parable from the Bible? The victim of a highway robbery lay wounded by the wayside and nobody lent him a hand. Then the Good Samaritan came along with the happy ending! What would the Samaritan do if the Bible were written in, say, the 1960s? Would he still act parabolically good? Not so good, says an article in the American *Journal of Personality and Social Psychology*. The authors, psychologists John Darley and C. Daniel Batson of the Princeton University, claim whether a Samaritan today would be good or not-so-good would depend on how hurried he is, what he is thinking about and what he believes in.

Indeed it was the parable itself which made them set up the experiment. (" Bystander Apathy " has been John Darley's preoccupation for a long time. See SCIENCE TODAY, January and February 1970.) The subjects were 40 students at Princeton Theological Seminary. They were first tested for their religious beliefs (or rather what religion meant to them). Then they were given two passages to read: one about possible future jobs for them and the other — the parable itself. They were then asked to go to another building to record a short talk on what they had read.

It was here that the " hurry " condition was introduced. Some were put in " high hurry " — being told that they were late already, some in " intermediate " hurry — the recording was about to begin and some were put in " low " hurry because they had plenty of time. On the way to the recording studio, a victim sat slumped in a doorway, " heads down, eyes closed, coughing or moaning intermittently ". Was he offered any help? Only by 16: the other 24 walked on!

The psychologists underline the " hurry " factor as the only significant explanation. In " low " hurry condition, 63 per cent helped; in " intermediate " hurry — 45 per cent; and in " high " hurry — only 10 per cent.

What is the moral this time? Could be this: *As the speed of our daily lives increases, ethics becomes a luxury!*

P. P.

Who is what in electronics?

A reader has sent in the following curious observations:

- **Mr. H. N. Sethna is Chairman of the Atomic Energy Commission (AEC). He is also Secretary to the Government of India in the Department of Atomic Energy (DAE). He is also Chairman of the Electronics Corporation of India Ltd (ECIL) — an industrial undertaking under the DAE. Again as Secretary to the DAE, he is a member of the Council of the Tata Institute of Fundamental Research (TIFR), 90 per cent of whose funds come from the DAE.**
- **The TIFR is of course headed by Professor M. G. K. Menon who is also Secretary to the Government of India in the Department of Electronics. He is also Chairman of the Electronics Commission. And a member of the Space Commission.**
- **Dr. R. Ramanna is Director of the Bhabha Atomic Research Centre (BARC) at Trombay. He is also a member of the AEC. And a professor at TIFR. And now also Chairman of Bharat Electronics Limited (BEL) at Bangalore.**
- **When Professor Menon wants funds for the TIFR, he has to ask Mr. Sethna. Yet, as Chairman of the Electronics Commission, he decides the overall policies of both ECIL (headed by Mr. Sethna) and BEL (headed by Dr. Ramanna who is under Mr. Sethna in the DAE).**
- **ECIL is an offshoot of the R&D in electronics carried out at BARC. In a way, it is a competitor to BEL. BEL has now collaborated with the TIFR in making integrated circuits. And BEL has as its Chairman the Director of BARC.**
- **Professor Menon is basically a particle physicist. Dr. Ramanna is a nuclear physicist. Mr. Sethna is a chemical engineer.**

The reader says he is confused!

astronomy's christmas gift

COMET

WHAT ARE COMETS?

M. V. K. APPARAO

YOU may have already seen it, if you are an early riser — a spectacular streak of white sweeping the dawn sky. Some astronomers believe the appearance of this comet (named KOHOUTEK after the discoverer) may be the event of the century. Some hail it as astronomy's Christmas gift. Some laymen call it inauspicious because, they say, it brought the bloody war in the Middle East. What are comets?

Ask the ancients. The Hindu mythology mentions *dhumaketu* whose appearance was considered to be inauspicious. (Understandably though, because comets were freak visitors that came and went away and were not a part of the regular order of the heavens.) The Greeks too had a name for it and an explanation. In fact, the name ' comet ' comes from the Greek word *kometos* which means long-haired star, describing the characteristic appearance of a comet. (The name could also have come from the Latin *coma* meaning hair.) The early Greeks believed comets were somehow associated with the Earth. Aristotle thought these were some exhalations (gas) from the Earth which rose high in the atmosphere and got kindled at high altitudes. Absurd as the idea seems now, it was widely accepted and for sometime comets were not considered heavenly bodies.

It was Tycho Brahe, in the 16th century, who restored comets to their place amongst heavenly bodies. He observed that the position of a comet in the sky does not seem to vary when observed from two places about 650 kilometres apart at about the same time. Even the Moon which is about 400,000 km away will be found to vary in direction if seen from two places far apart. Therefore, Tycho Brahe concluded, comets must be farther than the Moon.

There were attempts since then to understand the movement of comets, but a substantial advance could be made only after Newton announced his theory of gravitation when he suggested that the planets moved around the Sun due to an attractive force between them and the Sun. Halley applied this theory of gravitation to comets and solved the mystery of their unusual movement in the sky.

A COMET CAN HAVE three kinds of orbits due to the gravitational force of the Sun — it can be an ellipse, a parabola or an hyperbola (Fig. 1). If the comet approaching the Sun does not have enough speed to overcome the force of the Sun's gravity, it will move around the Sun in an elliptical orbit like our Earth does. (The nature of the ellipse can be described by its eccentricity. A circle has an eccentricity of zero, and as the eccentricity increases, it gets elongated and when it reaches the value of 1, it is termed a parabola.) A comet which has just enough speed to overcome the Sun's gravity will describe a parabolic orbit. If its speed is fast enough to overcome the pull of the Sun, it will be deflected by it and will escape into space. Such a comet will describe an hyperbolic orbit. Most of the observed comets have eccentricities close to one, though there are some with smaller eccentricities. Comets are found to approach the Sun from all directions (Fig. 4). In contrast with the orbits of planets, which lie in the same plane, the cometary orbits are inclined at all angles to the plane of planetary orbits.

KOHOUTEK

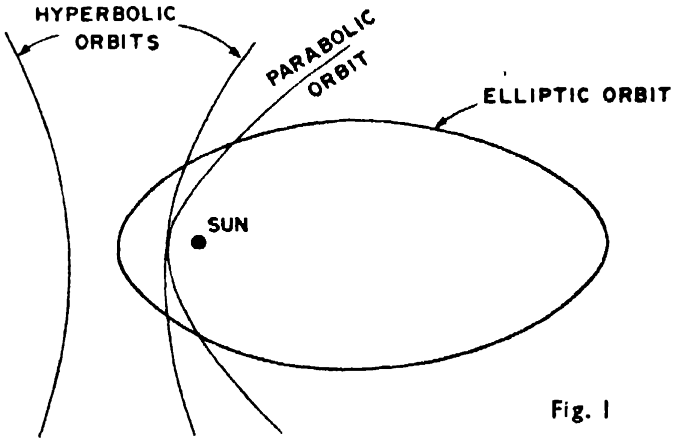


Fig. 1

How does an astronomer determine the cometary orbits? When he first discovers a comet as a small fuzzy object in the sky several billion kilometres or more away, he measures the position of the comet for several nights. From these measurements, the orbit is predicted by computation. Subsequent measurements are used to make the prediction more precise. Comet Kohoutek's predicted orbit is shown in Fig. 6 (on p. 34). It can be seen that the orbit of the comet is inclined to the plane of the Earth's orbit. Kohoutek will be closest to the Sun around 28 December (the closest position of the orbit is called perihelion).

BY MATCHING THE orbits of the various comets observed,

Halley's Comet

In 1705, Edmund Halley announced his calculations of the motion of comets near the Sun using Newton's theory of gravitation. He found that the orbits of some bright comets that came near the Sun in 1531, 1607 and 1682 more or less coincided. He concluded correctly that it was the *same* comet returning every 75 or 76 years. Accurate calculations were made and the comet was expected to arrive near the Sun in 1759 and it did. It was found by subsequent investigation that there were records of its return at intervals of 74 to 79 years since 240 BC. The period varies because of the gravitational pull of the planets when the comet nears the Sun.

The return of the comet was a great event in 1910 when it was visible to the naked eye from 11 February to 11 June. One puzzling feature noted by scientists during that year was the frequent changes occurring in the head of the comet in a matter of hours. The head seemed to be on the verge of breaking up ; however, the comet went away in one piece. Halley's comet is due to return in 1986.

astronomers found that many comets keep coming near the Sun again and again, implying periodic orbits. Based on these periods, comets can be classed into two distinct groups — the short period group and the long period group. The short period comets have periods of less than 100 years and about half of these have periods of less than 10 years. Among the long period comets, a majority have periods of over 1,000 years — the average period is estimated to be about 40,000 years. These estimates are of course made from predictions, because our observation does not span such long periods and the comets are not seen on successive returns.

About six comets get discovered every year, even though only about three or four are really new, the others being old periodic comets on their return trip. There have been exceptional years like 1932 and 1947 when 13 comets have been seen. The above rate of observations implies that there should be about 300 comets observed every century. If the average period of a comet is taken as 40,000 years, there should be about 120,000 comets in the solar system which come near enough for our observation. There can be many more which execute their orbits far away from the solar system and are not observable by us.

Appearance of a comet

A COMET AT FIRST sight looks like a hazy globule of light from which a tail extends. It has usually a silvery gray appearance, even though sometimes colours like red, blue or yellow appear. A close scrutiny shows that the comet contains three parts (Fig. 2)— a coma, a nucleus and a tail. The nucleus and the coma together are sometimes called the head of the comet.

The coma often appears as a diffuse, nebulous glow near the end facing the Sun — often round but sometimes with other shapes. As the comet approaches within a few hundred million km of the Sun, it emits light produced within itself. This light reveals that the comet contains chemical fragments from water (H_2O), methane (CH_4) and ammonia (NH_3). From these observations, it is conjectured that the nucleus contains swarms of solid particles embedded within these gases. The whole mass is solidified when far away from the Sun. It is thought to be more like a " dirty iceberg " by some scientists. As the comet approaches the Sun, the volatile gases in the nucleus evaporate and form the coma leaving the nucleus as a swarm of small rocky or metallic particles.

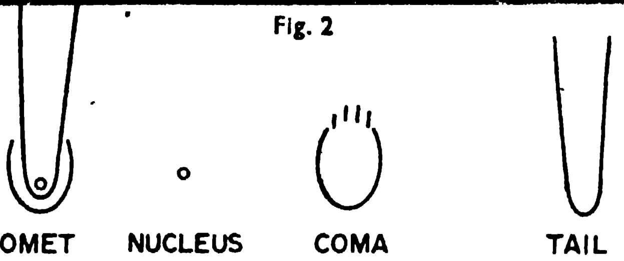
"Magnitude of stars"

WHENEVER stars are talked about in terms of their brightnesses, we hear of "star magnitudes". What are these star magnitudes?

In the second century BC, a catalogue of about a thousand stars was made by Hipparchus through observations with the naked eye. He divided these stars into six groups of brightnesses; these groups are now termed magnitudes. The brightest star was put in the group of first magnitude and the faintest was assigned to the sixth magnitude. Other stars were placed in groups in between. It is known that our eye sees equal ratios of light energy as equal intervals. Thus it was found that a star of 1st magnitude is about 2·5 times as bright as one of the 2nd magnitude, the 2nd magnitude star 2·5 times as bright as the 3rd magnitude one and so on. This scale was adopted in 1856 by all astronomers using a more accurate factor of 2·512 as the ratio between magnitudes. A difference of five magnitudes is equal to a factor of 100.

Star Aldebaran was assigned magnitude 1·0 and all other star magnitudes are measured with respect to this. An idea of the magnitudes of some celestial objects is given in Table 2. Notice the negative sign of some magnitudes. That means the object is *brighter* than the star Alde-

Fig. 2



Above: Fig. 2 Different components of a comet.

Below: Fig. 3 Reverse photograph of comet Mrkos showing two tails — the almost straight ray-like tail composed of gas and the curved diffuse tail made up of dusty material. Facing page: Fig. 4 The shape of the comet tail as it goes around the Sun. Note the tail is always away from the Sun and this is partly due to the force of Sun's light on the comet material

Table 1

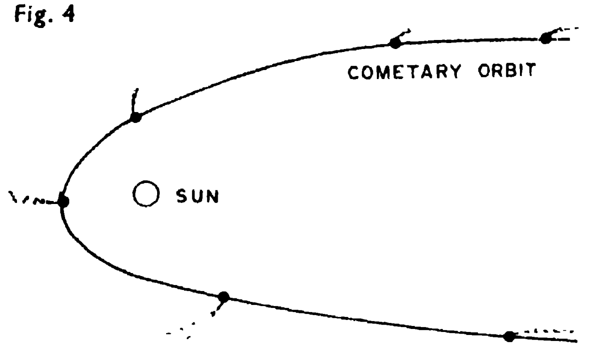
Difference in magnitude	Ratio of light
0	1 : 1
0·5	1·6 : 1
1	2·5 : 1
2	6·3 : 1
5	100 : 1
10	10,000 : 1
20	100,000,000 : 1
25	10,000,000,000 : 1

Table 2

OBJECT	MAGNITUDE
Sun	—26·5
Full Moon	—12·5
Venus	— 4
Star Aldebaran	1·0
Naked eye limit	6·5
6-inch telescope limit	13
World's largest telescope (photographic) limit	23·5

baran. Thus the more negative the magnitude, the brighter the object, and the more positive the magnitude, the fainter it is. The Sun is 40 billion times brighter than the star Aldebaran.

Fig. 4



The most visible feature of a comet is its tail (Fig. 3). A comet does not possess a tail when far away from the Sun and develops one only when about 320 million km away from the Sun. Some comets have more than one tail — one of the tails may be straight and pointing away from the Sun, while the others may be curved as seen in Fig. 3. The tail always points away from the Sun (Fig. 4) and when the comet is moving away from the Sun, the tail precedes the cometary motion. This may imply that the tail is due to some driving force from the Sun.

The tail grows as the comet approaches the Sun and sometimes reaches a length of 160 million kilometres, occupying a good part of the sky. It is conjectured that the tail material is first ejected from the head by the heating caused by the Sun, together with the collisions between the swarms of particles in the head. This ejected material executes its own orbital motion around the Sun. The Sun's light exerts a force on the smaller particles and makes them form the straight tail, while the larger particles, not much affected by the sunlight, form the curved tail. The light emission from the tail is, as mentioned earlier, partly due to reflection of the sunlight and partly due to production of light by its own material heated by the Sun.

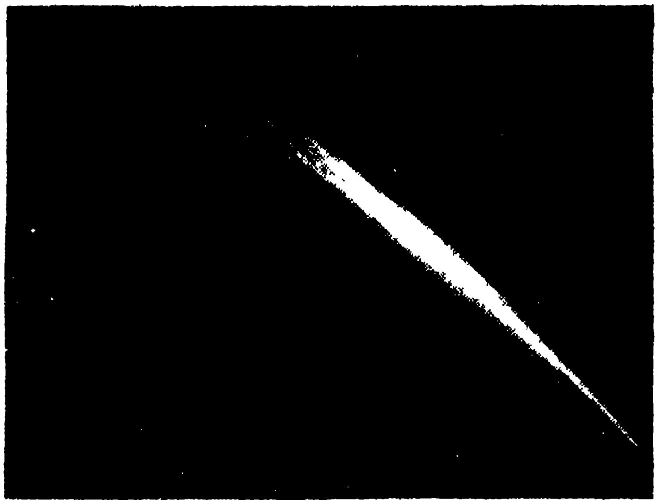


Fig. 5 Ikeya-Seki (seen in October 1965). Note the long tail and its fine structure

Origin of comets

WE HAVE SAID, on an estimate, the solar system may contain as many as 120,000 comets. Where do they originate? Scientists are not unanimous on the answer to this question. Some believe that comets, like our planets, are formed from the primeval material from which the Sun itself condensed. According to them, because comets normally execute orbits which do not bring them too close to the Sun, they survive for billions of years. Only some comets are disturbed from their orbits by planets which then bring them within a few hundred million km and we see them. These comets execute periodic orbits and are usually destroyed in a few million years.

There are some scientists, however, who believe that comets are freshly formed from material attracted by the Sun when it enters a cloud of gas. These clouds of gas are known to exist in interstellar space and the Sun in its motion amongst the stars can enter one of these clouds. The material attracted by the Sun can finally condense to form comets which go around the Sun. Scientific opinion is divided between these two theories. Again, it is possible that both the processes may contribute to form the action of comets.

Kohoutek

KOHOUTEK WAS discovered accidentally in mid-March this year by Lubos Kohoutek of the Hamburg Observatory in West Germany while he was looking for a minor planet. When he first observed it by means of a telescope, it was a faint object indeed; but as more measurements were made of its orbit and its increasing brightness, scientists were astonished. The comet has been increasing its brightness at a faster rate than expected, and when closest to the Sun, as per predictions, should be as bright as the planet Venus, the bright object we sometimes see in the western sky. Some astronomers feel that the comet's brightness may almost approach that of a full Moon.

The comet is coming from below the plane of the Earth's orbit and should be visible to the naked eye by early December. In mid-December it will be 25° west and south of the Sun and will be visible for an hour and half before sunrise. The tail can occupy as much as 30° of the sky (there are 90° between the zenith overhead and the horizon). The comet will cross the plane of the orbit of the Earth by 27 December and the following day it will be closest to the Sun (perihelion). It will be at its brightest, but due to its closeness to the Sun, may or may not be visible to the naked eye, but will certainly be visible through a telescope.

Then it will quickly move to the north of the Sun and will be visible in the evening between 10 and 20 January 1974, when it will be seen at its best from the Earth after sunset. It will be closest to the Earth, about 120 million kilometres away, on 15 January 1974. As the comet recedes from the Sun, it will become dimmer and after February may not be seen by the naked eye, even though it will remain visible through telescopes till 1975.

Dr. Krishna Apparao is with the Cosmic Ray Group at the Tata Institute of Fundamental Research, Bombay. A PhD from the University of Rochester in USA where he worked for some time, he was also a member of the Harvard University Faculty and the Smithsonian Astrophysical Observatory during 1968-69. He is currently engaged in astrophysical research relating to cosmic rays, pulsars and celestial X-ray sources.

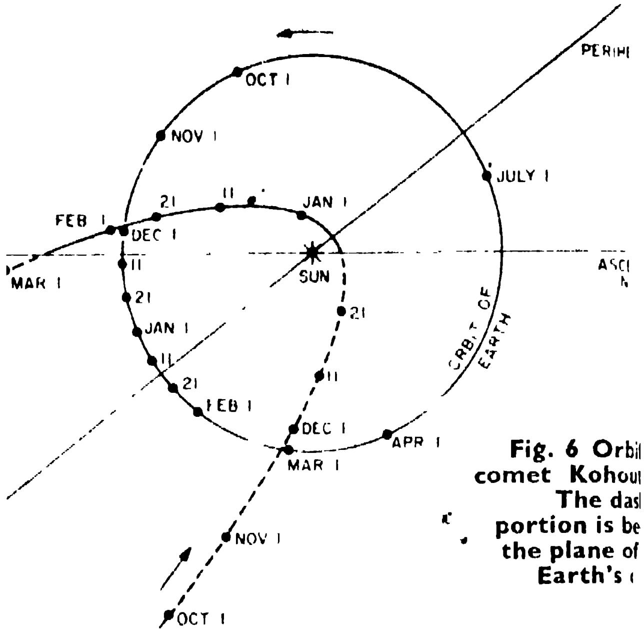


Fig. 6 Orbi comet Kohou The das portion is be the plane of Earth's

About Comet Kohoutek

- **Discovered photographically by Dr. Lubos Kohoutek on 7 March 1973 at Hamburg Observatory in West Germany with the 32-inch Schmidt telescope.**
- **Comets are named after their discoverers. Kohoutek is designated 1973f, the "f" meaning it was the sixth comet to be discovered this year. The fifth was comet Kohoutek 1973e, discovered about a week earlier by the same Dr. Kohoutek.**
- **The orbit of Kohoutek is inclined at 14° to the ecliptic — the plane of the Earth's orbit around the Sun.**
- **Estimated brightness ranges from visual magnitudes -2 to -10. (Moon's brightness is -12·7 magnitude).**
- **Naked eye visibility which began in late November prior to sunrise will switch to after sunset when the comet passes perihelion (closest approach to the Sun) on 28 December. Best viewing may come in the evening twilight shortly after 1 January. Then full Moon will interfere until the last third of January. At perihelion, the tail will appear short because Earth view will be almost directly along its tail.**
- **Kohoutek is believed to be a long-period comet (10,000 to 80,000 years, against Halley's 76 years) and this may be the first time it has approached the Sun.**

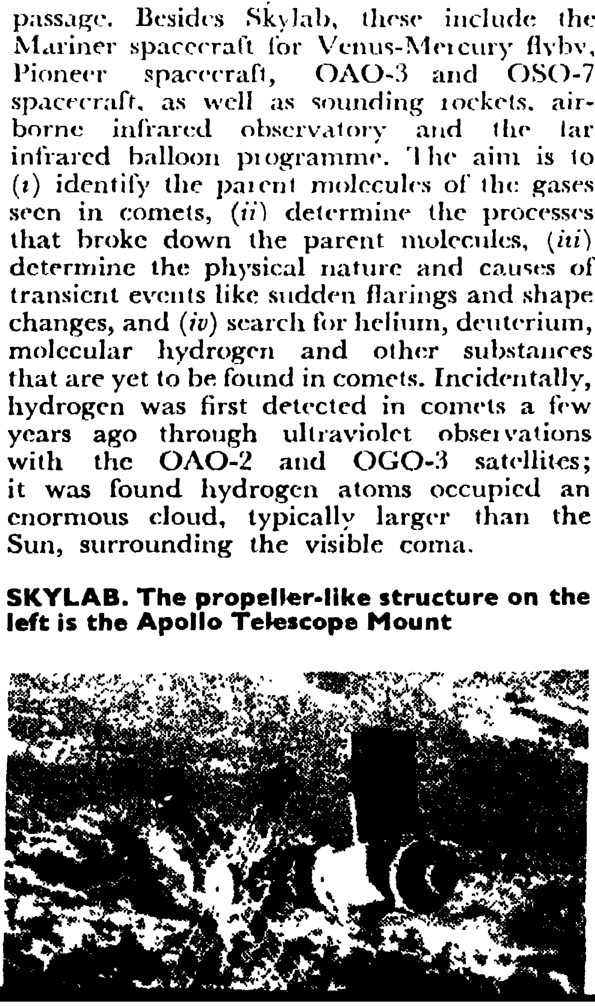
A "Space-window" view

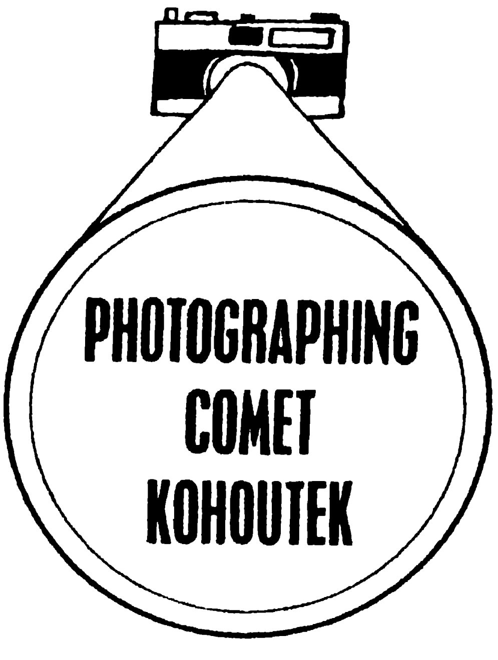
TILL now, scientists knew very little about the physical nature of comets, though recorded evidence dates back to 467 BC. It is now believed that the clue lies in the ultraviolet, infrared and microwave regions of the cometary spectrum.

Skylab 4, the third and last manned mission in this series, is the most privileged observer of comet Kohoutek's visit to the solar system. In fact, it will be a grand-stand view, far above the distorting layers of Earth's atmosphere, from where its crew can monitor the changing composition of the comet in the ultraviolet spectrum. Their most important tool: the Apollo Telescope Mount (ATM) with its array of eight telescopes. It can observe Kohoutek at perihelion (its closest approach to the Sun) when the comet is brightest and receives the most solar energy. At that time, ground-based observations have very limited scope, due to scattered sunlight in the atmosphere.

The US space agency, NASA, plans to use several observation systems to cover Kohoutek's passage. Besides Skylab, these include the Mariner spacecraft for Venus-Mercury flyby, Pioneer spacecraft, OAO-3 and OSO-7 spacecraft, as well as sounding rockets, airborne infrared observatory and the far infrared balloon programme. The aim is to (*i*) identify the parent molecules of the gases seen in comets, (*ii*) determine the processes that broke down the parent molecules, (*iii*) determine the physical nature and causes of transient events like sudden flarings and shape changes, and (*iv*) search for helium, deuterium, molecular hydrogen and other substances that are yet to be found in comets. Incidentally, hydrogen was first detected in comets a few years ago through ultraviolet observations with the OAO-2 and OGO-3 satellites; it was found hydrogen atoms occupied an enormous cloud, typically larger than the Sun, surrounding the visible coma.

SKYLAB. The propeller-like structure on the left is the Apollo Telescope Mount





PHOTOGRAPHING COMET KOHOUTEK

M. W. CHIPLONKAR

WHEN comet Kohoutek was accidentally discovered on a couple of plates exposed by Dr. Kohoutek in March 1973, it was a very faint nebulous object of star magnitude 16 without any significant tail and was 4·7 A.U. away. (An astronomical unit or A.U. is the distance of the Sun from the Earth—149·6 million km; Jupiter's distance from the Sun is about 5·2 A.U.) Professional astronomers with their sophisticated modern equipment are already busy accumulating and scrutinising their day to day observations. And amateur astronomers are no less excited. This is going to be a unique event and even the novice photographer would like to have a go at it with his little camera.

A photographer is interested in two major characteristics of a comet—its long wispy tail with its delicate shades of silver grey colour, and its very rapid movement across the dark background of a starry sky. In the case of comet Kohoutek, apart from its exceptional brilliance which may make it visible sometimes even in the (sunlit) day sky, both the above characteristics are well anticipated to be almost unprecedented during the last 60 years.

Generally the tail of a comet is developed enough to become its special feature only when it has approached the Sun to within a distance of about 1·5 to 2·0 A.U. In the case of comet Kohoutek, no astronomer has yet predicted with confidence the maximum possible length of its tail during its nearest approach to the Sun. However, since the perihelion distance of Kohoutek has been predicted to be very small (0·14 A.U.), and its brilliance then is also expected to be from −8 to −10 star magnitude, we may as well expect its tail to be as long, if not longer, as that of Halley's comet. In its most favourable position, the tail is also likely to make an angle of about 95° to 110° to our line of sight by mid-January 1974. Further, in accordance with Kepler's second law of planetary motion, the speeds with which it approaches and recedes from the Sun while passing around the perihelion point will be very high. Thus, both these conditions mean that our camera must have a wide enough angle to accommodate in its field the fully developed long tail and it should also be fast enough to allow the shortest time exposure with the fixed camera, so that the movement of the comet does not produce too much of a blurring effect.

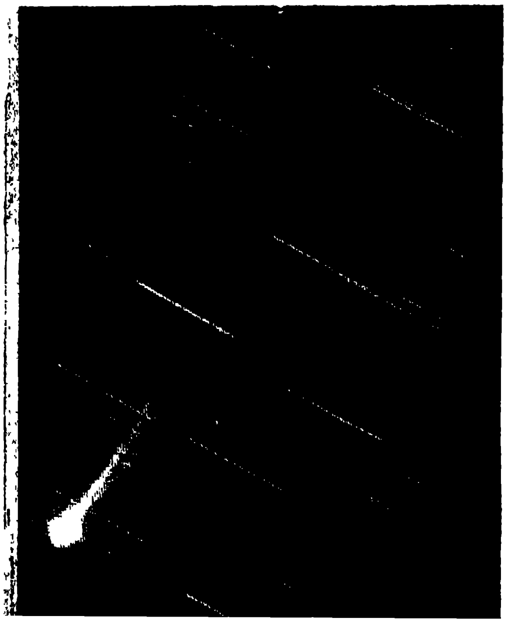
WIDE-ANGLE CAMERAS

are not very common, but one can at least induce somebody who owns it to use it freely on this occasion. Some professional astronomers and research scientists, and probably a few private photographic studios and cine studios may have them, especially for their wide-angle shots in enclosed places. Too wide an angle camera like the " fish-eye " or " all sky camera " is not necessary.

Once a suitable wide-angle (say, 50°) camera is secured, the next step would be to practise astronomical photography of faint-moving objects in the night sky. Obviously, this should not be done in the light- and dust-polluted atmosphere of a modern city! It would be worthwhile to go far away from the city lights and expose a few shots with the maximum aperture of the camera opened, each for at least a few minutes. During such exposures, the camera should be firmly held on a rigid stand and pointed at a portion of the sky (preferably above the eastern or the western horizon where this comet is likely to be seen) with a number of bright as well as faint stars. They will show bright and faint curved trails of star images on our plate due to the diurnal rotation of the Earth on its axis (Fig. 7). Referring to an accurate star map, these stars could then be identified and the angular separations of different stars easily estimated.

It will be clear at once that since the star images are trailing over the plate and not staying permanently at their same respective places, the density of the trails does not increase

Fig. 7 Comet Finsler photographed in 1937. Streaks are trails of starlight during the 5-hour long exposure when the comet moved ralative to the background stars



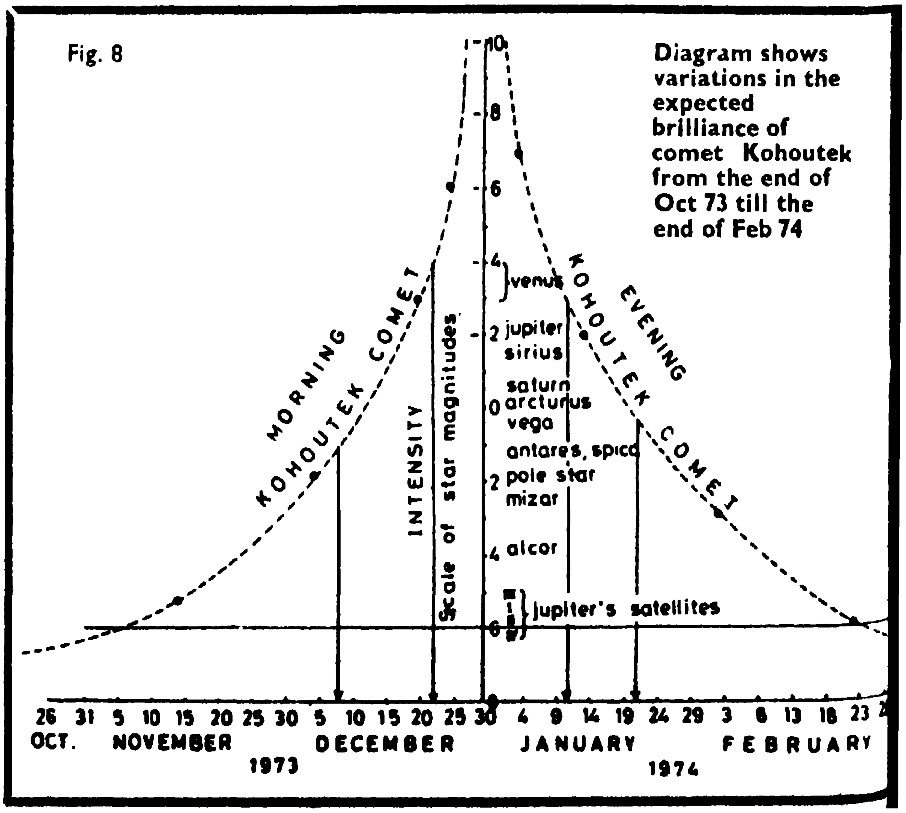


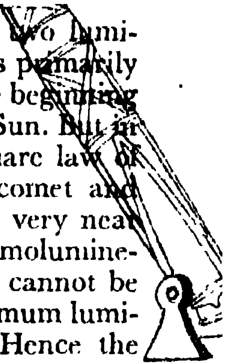
Fig. 8

Diagram shows variations in the expected brilliance of comet Kohoutek from the end of Oct 73 till the end of Feb 74

whatever the exposure; it only increases with the increase in the aperture of the camera lens. Hence, resorting to longer exposures to overcome the limitation of the maximum aperture of the available camera and the faintness of the sources of light such as a comet's tail, is pointless.

We can, however, keep the camera continually moving slowly in the same direction as the starry firmament so that the images of stars — especially in the central portion of our plate — remain at their same respective places on the plate during the complete duration of the exposure, which can then be anything from a few seconds to something like a few minutes and even hours. The cumulative effect of light on the emulsion will then bring out all that we want in the picture, particularly the faintest stars several magnitudes lower down the intensity scale. It must be remembered here that this technique of turning the camera to counteract the apparently moving stars is not so straightforward a business when we employ it for photographing a comet, since one has to allow for the diurnal motion of the Earth, that of the comet in its orbit and the orbital motion of Earth too. Hence, while photographing this comet it is advisable to counteract the motion of the comet completely and leave the other two only partly counteracted depending upon the particular epoch. Naturally, the novice astronomical photographer will have to practise this first with a camera mounted equatorially and driven continuously by a clock-drive (clock-drive is a clock mechanism generally driven by a falling weight. It is connected to a telescope mounted equatorially to turn it gradually about the polar axis and adjusted to exactly counteract the Earth's diurnal motion) and then, take over the driving operation himself and carry it out manually during the time of exposure. This will effectively increase the exposure and a more brilliant image will result even if the maximum aperture is insufficient for the luminosity of the object — in this context, the tail of this comet.

HOW BRILLIANT is the comet Kohoutek? Fig. 8 shows the variations in its expected brilliance as it approaches and recedes from the Sun from the end of October 1973 to the end of February 1974. This is the period of all the expected significant changes in the life of this comet—in its external appearance, internal structure and largescale bodily movement. It will be noted in this figure that the range of star magnitude covered is from about +10 to −10 — almost a ratio of more than 100 million between the two luminosities. This photometric estimate is primarily based on its very great distance at the beginning to a final very close approach to the Sun. But in addition to this effect of inverse square law of photometry between the Sun, the comet and the Earth, when this comet will be very near the Sun, the fluorescence and chemoluminescence effects on its material, which cannot be forecast easily, may ennance its maximum luminosity of −10 magnitude further. Hence the spectroscopic analysis of the emitted light from time to time is of prime importance to the professional astronomer. Also a knowledge about the nature of polarisation of the light received from the comet from time to time is equally important.



IT WOULD BE worthwhile if a group of enthusiastic amateur photographers and amateur astronomers come together to pool their resources and cooperatively carry out a well thought-out plan of studying this brightest comet of the century during its perihelion sweep. A single firmly mounted telescope with a clock-drive (simple gravity driven) and a few cameras varying in their apertures, fields and focal lengths would be quite enough. Two or three of these selected cameras could be strapped tightly around the main telescope and all adjusted accurately to point in the same direction. The telescope itself is then used as a guide during the exposure. Of course, the clock-drive of the telescope must not be overloaded; the telescope should be well balanced and the turning should be as smooth and easy as possible.

It would save much effort, money and material if this group very carefully inspects and studies beforehand, from the photographer's point of view, a number of photographs of as many earlier comets as possible which are already published in the astronomical literature.

But much of the final outcome will depend upon how detailed all operations and relevant observations have been recorded on the spot from time to time. This would help to a great extent in improving upon the results as the comet attains its maximum grandeur.

Dr. Chiplonkar, who was awarded his DSc in physics by Bombay University, was Professor and Head of Physics, Poona University, until his retirement in 1969. Since then he has been working as a UGC University Professor under the Retired Teachers' Scheme in Poona University. He is an active member of several international astronomical societies.

what is science really about?

PART II

R. NARASIMHAN

What are scientific theories theories of? In Part I, the author's answer was: "They are theories of experiments. The popular view that science is about the naively observed regularities of nature is somewhat simplistic. Uniformities and regularities relate only to experimental situations."

Science begins, the author said, with the question why something happens and exploratory experiments are carried out to construct a theory. Again, further sets of experiments are required to verify the theory. After verification, the theory can be axiomatised, depending on the availability of other background theories and the quality of the experimental apparatus. That again would depend on the level of technology.

In this concluding part, the author distinguishes between the set-up for physical and behavioural sciences and shows the social relevance of science lies in taking it from the prediction-verification stage to the control and manipulation of the environment to realise some social objective

EARLIER in dealing with experiments, we noted that two basic prerequisites to performing experiments are, (1) a language in which specifications for an experiment can be given, and (2) an agent who could interpret these specifications and carry out the experiment. Scientific activity is thus predicated on the existence and availability of (language-using) agents. The agentive aspect of an agent consists in the possession of a *repertoire of actions* using which the agent is able to explore, monitor, and manipulate the environment in various ways.

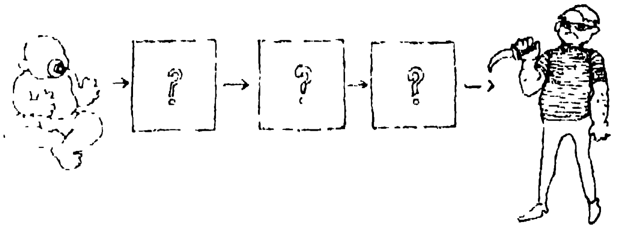
Occurrences of natural phenomena in the commonsensical world can be divided into two broad classes: (1) those occurrences involving only objects, and (2) those occurrences involving at least one agent. (Objects can be distinguished from agents by the fact that agents are sources of actions while objects are not.) Let us call the first class of occurrences " physical situations ", and the second class " behavioural situations ". Physical sciences relate to physical situations and physical theories are set up to account for occurrences encountered in such situations. Behavioural sciences relate to behavioural situations and behavioural theories are set up to account for occurrences encountered in such situations. If more than one agent is involved in a behavioural situation, the corresponding science is called the science of group behaviour or social behaviour. If only one agent is involved, the related science is called the science of individual behaviour.

PHYSICAL SCIENCES. Explanations in the physical sciences can be divided into two principal types. Firstly, we have a class of explanations that account for the properties of objects and their states. Scientific theories usually provide such explanations in terms of the properties and relationships of subobjects of which that object is considered as built up. For example, properties of a crystal are explained in terms of the atoms that compose the crystal and their interrelationships. A property of a fibre may be explained in terms of the properties of long-chain molecules which are the building blocks of the fibre. And so one. One of the fundamental goals of physics is to answer the question: " What are the ultimate constituents of matter (i e, of objects) ? ". This should not be interpreted as a metaphysical question relating to some ultimate " external reality ". The issues involved are of a purely theoretical nature and relate to the kinds of theoretical terms that have to be postulated in order to explain the variety of observed phenomenological details concerning objects.

The most convincing vertification of such analytical explanations is through synthesis. To demonstrate that object A is composed of objects B, C, D in some specified way, the best method is to synthesise A starting from B, C, D, by putting them together in the way specified by theory. In this way, one can explicitly exhibit how specific properties of A depend on the properties of B, C and D. Technological breakthroughs in the manufacture of new products having desired properties are based on our capacity to accomplish such synthesis.

The second class of explanations in the physical sciences is concerned with the occurrence of specific physical *processes.* In Newtonian Physics (from Newton up to and including Maxwell), it was thought that all physical processes could be explained in terms of motions of material particles. Subsequent developments in electromagnetic theory showed that one should consider a ' field ' as much a fundamental entity as a ' particle '. One of the basic unresolved theoretical problems of physics is this: " Is it essential to treat both ' fields ' and ' particles ' as fundamental entities, or can we dispense with one of these classes ? "

The basic relationship between physical objects and physical processes can be seen as follows. The possibiltiy of creating objects through synthesis (in the broad sense, including transformations and decompositions) presupposes a synthesising process that realises specified objects. The study of naturally occurring objects could then be thought of as the study of naturally occurring physical processes that created these objects. How was coal created (formed) ? How was the Moon created (formed) ? How does object A transform into object B? And so on. Notice that answering such questions consists in describing experimental situations (processes) whose end results are the concerned objects.



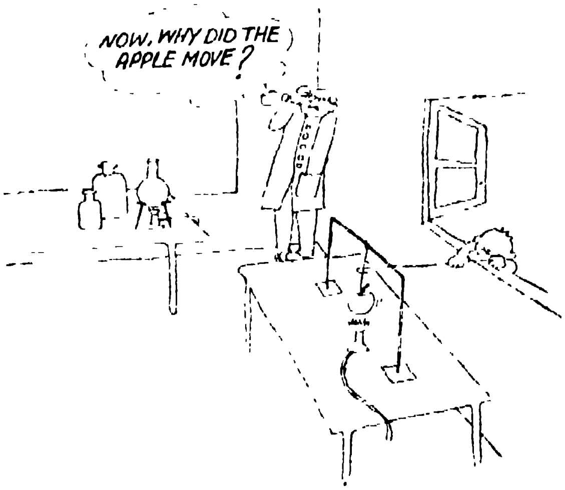
BEHAVIOURAL SCIENCES. Consider now the types of explanations that arise in behavioural situations. Behavioural situations relate to the behaviour of agents. For simplicity, let us consider individual behaviour to begin with. Since an agent is characterised by a repertoire of actions, we have to contend with three classes of explanations.

Firstly, we have explanations that relate to the nature of specific actions belonging to the repertoire of an agent, i e, explanations that answer questions of the type, " What does performing this action consist in ? ". What does swimming (say, in the case of a frog) consist in ? What does nest-building (say, in the case of a Weaver-bird) consist in? What does courtship behaviour (say, in the case of a stickleback fish) consist in? And in the case of human beings, what does reading consist in? What does responding to a spoken utterance consist in? What does solving a given puzzle consist in? And so on. Notice that at present we do not know how to answer many of these questions although they seem superficially transparent.

A satisfactory explanation of the nature of an action would presumably try to account for that action in terms of sub-actions suitably sequenced and related. Actions, ultimately, can only be accounted for in terms of information processing systems. For, actions manipulate the external environment and, hence, call for sensing and analysing the states of this environment, and require the deployment of appropriate control actions to arrive at the desired state of affairs. Information processing systems are designed precisely to accomplish these.

A second class of explanations arises when one asks how some specified action is realised in an agent. This is the class of explanations that is given at the level of anatomy and physiology, or biology. Clearly, explanations of the first class logically precede explanations of the second class. Realisation of actions in an agent can be meaningfully explained only after we have an analysed account of the nature of these actions. Before we can answer " How is shape-perception realised in man? ", we must have a technically articulated account of what shape-perception consists in.

A third class of explanations arises when one tries to account for particular occurrences of actions. These explanations try to answer questions of the following type: Why did the rat jump to the right (in an experiment, say)? Why does the subject raise his foot now? Why is her pulse-rate high now (referring to the state of an agent)? Why did the man kill his wife? And so on. A scientific theory of individual behaviour must be able to postulate a set of behavioural laws, we assume, on the basis of which the occurrences of such specific events could be accounted for (or predicted). Presumably such laws would be of the form, " under such and such external and internal environmental conditions an individual is likely to exhibit this and this behaviour ".


NOW, WHY DID THE APPLE MOVE?

MUCH OF ACADEMIC psychology has been preoccupied with the formulation of such " laws " to predict behaviour. However, as we have been emphasising repeatedly, scientific laws do not relate to situations of the open-ended world but only to experimental situations. Laws of behaviour, even if we are able to enunciate them, can be applicable only to behaviour realised under strictly controlled circumstances. Both the external and internal environments of an agent have to be under rigid experimental control in order for theoretical predictions to be verified.

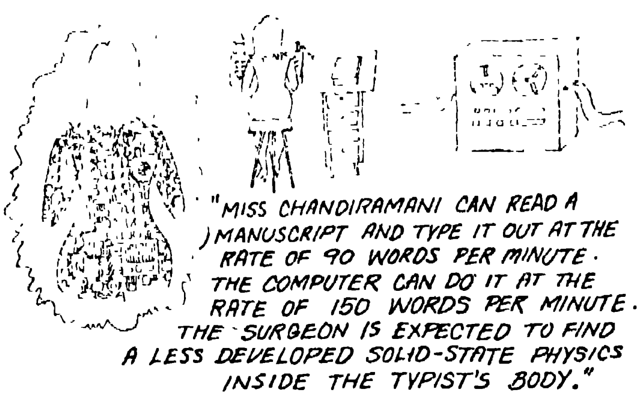
It may well turn out that significant aspects of behaviour of most organisms cannot be realised under rigid experimental conditions. Also, the kinds of experimental conditions a science of behaviour may demand to control behaviour may be incompatible with socially acceptable boundary conditions. Hence, experiments carried out, and results obtained, on the control and prediction of behaviour within the confines of a laboratory may well turn out to be of little relevance to behaviour encountered in the open-ended situations of real-life.

Even granting that prediction and control are the most important applications of science (see below for further comments on " applying science "), it is not clear that a science of behaviour can attempt to cope with these without first coming to grips with the first two categories of explanations. Knowledge of the nature of behavioural acts and of the mechanisms that underlie behaviour, clearly, is a prerequisite to any attempts at control or shaping of behaviour.

IT WOULD BE A fallacy to think that problems of behaviour could be reduced to physics and chemistry in any meaningful sense. One can see the force of this assertion perhaps better through an analogy. Suppose that we are able to construct a special-purpose computer that is able to read handwritten documents and transcribe them into typescript. At present we do not know how to build such machines, but let us assume we have been able to solve this problem. It is now required to explain how the computer is able to accomplish this. Assume that a man who is trying to puzzle this out opens the computer and finds it full of transistors wired together in complex networks. Would it not be odd if he were to jump to the conclusion that solid state physics is the appropriate basis for understanding and explaining the handwriting-reading behaviour of this computer?

The study of behaviour is firstly concerned with the articulation of information processing systems that can account for the agentive aspects of agents. We must analyse behaviour by asking ourselves, ‘ What does doing something amount to? " What does building a nest consist in? What does identifying a shape consist in? What does using a language consist in? As we discussed earlier, these questions have to be answered by saying, " doing this consists in doing this and this and this in these coordinated ways ". Then we can analyse how does one do this and this and this and coordinate them in these specific ways. What kinds of primitive processes are involved? What kinds of boundary conditions have to be obeyed? How does the behaving agent verify that a given boundary condition is in fact satisfied? And so on and so on in finer and finer details.

We cannot get very far in the study of behaviour by merely dealing with psychological terms at the verbal level. What is intelligence? What is memory? What is emotion? What is consciousness? Such questions sound profound at the surface level. But it is not clear that substantively such questions are very meaningful. Instead of raising these sterile *what-questions*, we should rather concern ourselves with *how-questions*. We observe an animal doing this and this. How does it do it? How can we characterise what it does procedurally? Can we construct a machine to simulate its behaviour? If we can construct such a machine, then we can try in terms of the behaviour of that machine to give substance to traditional terms like intelligence, memory and consciousness. We can then also go on to ask whether the animal is in fact put together in the way the machine is at the level of logical structure and functioning. Physics and chemistry come into the picture only when we get down to the study of specific hardware realisations of the postulated system structure and function.


"MISS CHANDIRAMANI CAN READ A MANUSCRIPT AND TYPE IT OUT AT THE RATE OF 90 WORDS PER MINUTE. THE COMPUTER CAN DO IT AT THE RATE OF 150 WORDS PER MINUTE. THE SURGEON IS EXPECTED TO FIND A LESS DEVELOPED SOLID-STATE PHYSICS INSIDE THE TYPIST'S BODY."

IN TRYING TO construct viable behavioural models to account for the agentive aspects of agents, one encounters difficult methodological problems. An agent can seldom be isolated in order to study the nature of specific actions, or the relationship between one action and another. Any interference with the status of an agent as an integral system quite often results in the destruction of the very agentive aspect one is trying to study. Exploratory experiments to study the nature of specific aspects of behaviour can only be conducted through indirect means. Quite often one has to rely on the performance of artificially constructed automata or computer simulated models. Studies of this type, which are sometimes termed "Artificial Intelligence Studies", are in an extremely rudimentary stage. Professional psychologists, unfortunately, are still very uninformed about the potential value of such studies.

So far we have been concerning ourselves exclusively with the study of individual behaviour. Study of social behaviour poses even more formidable methodological problems. Controlled experiments are extremely difficult to perform and, inevitably, many of the inferences drawn from observations of group behaviour tend to be highly controversial. At present we do not know how to evolve new methods of studying group behaviour which could lend themselves to exploratory experimentation. Exploratory experimentation, as we have seen earlier, is a necessary prerequisite to viable theory construction. And till we are able to construct dependable theories of group behaviour, we cannot hope to answer why-questions concerning such behaviour.

Science and technology

WE SAW EARLIER that a typical prediction from theory is of the form, " if you do such and such, then such and such will result ". It is the possibility of using this prediction in reverse that gives rise to the fundamental social relevance of science. Here, the primary concern is not prediction or verification, but control and manipulation of the environment (either external, or internal, or both) to realize some socially desirable end. In the control situation, typically, the desired end product, or the goal, is given. The problem is to determine the appropriate boundary conditions and the interaction procedure that would result in the desired end product. So, we can state the basic problem underlying scientific applications as follows; " what should I do so that such and such would result? ", or more precisely, " performing what experiments would result in the desired end objective? ".

A scientific application, then, is of the nature of performing a certain experiment. It consists in constructing an artificial world out of a delimited part of the natural world so that this artificial world can be made to approximate an experimental situation as closely as possible. An assembly line is an artificial world whose boundary conditions can be controlled much more closely than those in a village blacksmith's shop, say. A chemical plant is a scaled-up version of a chemistry experiment in a laboratory. An office, a school and a hospital are all artificially constructed worlds which lend themselves to greater or less scientific control. The more automated these are, the closer the control. It is clear from this description in what sense taking science into the world poses ethical problems. It is also clear how problems of pollution are inherent in applying science. The answer to both these categories of problems does not consist, of course, in withdrawing from science but in understanding the nature of these problems and in trying to see how the artificial worlds that we construct could be restructured so that these problems are resolved in socially desirable ways.

Science and Technology

WHILE a considerable amount of work has been done on the history and logic of science, the history of technology is still a scantily investigated field. It is only relatively recently that historians have started studying and documenting systematically the technological and engineering accomplishments of prehistoric men, as well as those that ante-date the age of science. Much of this technical literature is not readily accessible to the interested layman. An interesting set of papers, which originally appeared in the *Journal of World History,* have been collected and published as a paperback under the title, *The Evolution of Science* (Mentor, MQ 505, 1963). Among the articles, Gordon Childe's "The Prehistory of Science: Archaeological Documents" and Bertrand Gille's "Technological Developments in Europe: 1100 — 1400" are particularly noteworthy.

In agriculture, plant and animal breeding, and mining and metallurgy, the technological achievements that predate the 16th century are of an astonishing sophistication. It would not be an exaggeration to claim that the exploitation of all the natural resources (except of course petroleum products) reached a high level of sophistication through artisan-based technology. In the 12th, 13th and 14th centuries, machine tools driven by water-power and spring-loading were in extensive and routine use. Long before Henry Ford, assembly lines were in use in the shipbuilding industry of Venice. It has been claimed by some that many of the mechanical inventions of Leonardo da Vinci were, in fact, patterned on already existing engineering contraptions. Science-based technology began to come into its own only with the discovery of the laws of electro-magnetism. The more recent and spectacular advances in science-based technology are mostly concerned with the production and exploitation of artificial material, eg, synthetic fibres, plastics, synthetic rubber and, of course, petrochemicals.

A sound study of the history of technology should teach us the true relationships between the springs of innovativeness in a community and the level of development of artisan-based technology. There would seem to be little historical justification for the view that the level of technical innovativeness of a community is directly related to the level of its exposure to academic science. The implication of this view is that one should make a scientist of a man before one can hope to make a technologist of him. As Bertrand Gille notes, historically, quite the reverse seems to have been the case: "It was the endless recurrence of particular technical problems that compelled scientists to seek to define each one in general terms. In other words, experiment was born of technical experience, for technical experience is a perpetual experiment".

R. N.

Before science can be applied to solve a real-life problem we have to go through several stages of formulation. The informally stated social goal must be formally translated into an appropriate scientific framework. The goals so translated must be correlated with a suitable theory. This is by far the most difficult task in solving real-life problems. This, clearly, requires people who are well-conversant with theories *and* their technological implications. Having found a theory we must try and work out what antecedents and what procedures would lead to the desired end goal. If new technologies are called for to meet these constraints, they must be developed.

The social relevance of any field of science, in a given community, is finally determined by the kinds of technologies that that field of science relates to, and how necessary these technologies are to tackle the urgent problems of that community. Clearly, the greater the dissociation between science and technology, or between scientists and technologists, in a given community, the more difficult it would be to "justify" science socially, especially if science has to be paid for by society at large.

Successful application of science to real-life problems often requires a high level of competence in systems analysis and systems engineering. Systems engineering is concerned with the conversion of a conceptually analysed system into a working, engineered version. Such tasks can quite often be tackled only by teams of theorists, experimenters and technologists working in close coordination.

We have tried to develop in this article an account of science and of activities that give rise to science. And using this we have tried to clarify the relationship between commonsensical knowledge and scientific knowledge, and the roles experiments and theories play in the systematisation of scientific knowledge. Let us note once again that science as an organised activity presupposes the possibility of constructing experimental situations of various sorts. Engineering and technological accomplishments that precede science in any field precisely provide such a phenomenological delimitation on which science could be founded. After various agricultural practices have been successfully instituted, one can start a science of agriculture and ask why this and this happen? Why do these practices work? How can they be improved? And so forth.

This is not to deny, of course, that once scientific activity has been built up in an area, the scientific results could be fed back to refine, improve and strengthen the engineering practices. Heuristically arrived at procedures could be put on more rational foundations supported by scientific theory. New engineering possibilities, undreamt of earlier, could now be attempted based on the wider and deeper understanding provided by science. Thus, an artisan-based technology (or engineering) is transformed into science-based technology and engineering.

The recent spectacular successes of science-based technology, however, should not blind us to the seminal roles played by artisans and artisan-engineers in the growth of academic science. Artisan engineers are the true precursors of science.

There is a moral in this, not only to scientists wanting to grow new areas of scientific activity, but to those concerned with spreading the culture of science among the people at large. The problem of spreading science among the naive population cannot be tackled by merely exposing the people to academic science, or by disseminating popular accounts of academic science but, ultimately, only by transforming more and more of the population into artisan-engineers and by upgrading the level of existing artisan-based technology through the infusion of science.

CONCLUDED

in lighter moments...

CURIOUS, how some folks walk away with the credit that is not due to them!

If you have worked in a chemistry lab, you must have used the Bunsen burner practically daily. Well, Bunsen didn't invent this one, though it played such an important part in his work that the association with his name is but natural. His constant use of it made it very popular. It is considered that Michael Faraday was its inventor. Yet, if we dig deeper we find that the credit for the burner must go neither to Bunsen nor to Faraday but to a Heidelberg mechanic named Desaga. Bunsen himself wrote in a letter dated 12 May, 1855: "Mr. Desaga, mechanic in Heidelberg, has made a gas burner for heating, which is based upon a principle that I suggested, and which has been constructed in an ingenious form of his own design."

Poor mechanic, cruelly lost between two geniuses!

● ● ●

STILL stranger was the fate of the inventor of the miner's safety lamp, a protected flame lamp used for lighting in mines and for testing the safety of mine atmospheres. Most popular science history books describe Sir Humphrey Davy as its inventor. It is true that Davy too invented a lamp, but when a governmental committee investigated the hazards in British coal mines, even Davy's closest disciple Faraday testified that Davy's lamp was not always safe because it was liable to be overheated. Davy bore Faraday a lasting grudge for this, and blackballed Faraday's election to the Royal Society's fellowship years later. However, the great London scientist carried the day.

The coal miners of the North did not accept the London decision. They were still for their 'Geordie', the lamp invented earlier by the great engineer and locomotive builder, George Stephenson. This led to a fierce controversy between the rival supporters. Finally, the Davy lamp, incorporating improvements based on the designs of Stephenson and Clanny, was accepted in all British mines.

Three years after the London announcement, in 1818, the miners in Newcastle donated a fund of £ 1000 to Stephenson as a gesture of their gratitude and recognition.

● ● ●

THE German physicist, Gustav Robert Kirchhoff (1824-87) is said to have missed delivering only one lecture in the whole of his teaching life. This single miss happened when he was married. The marriage took place on a Saturday, and it was on this day that he used to lecture. On Sunday he celebrated his honeymoon and resumed lecturing the next day.

S. N. Munshi

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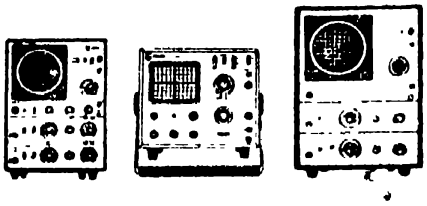

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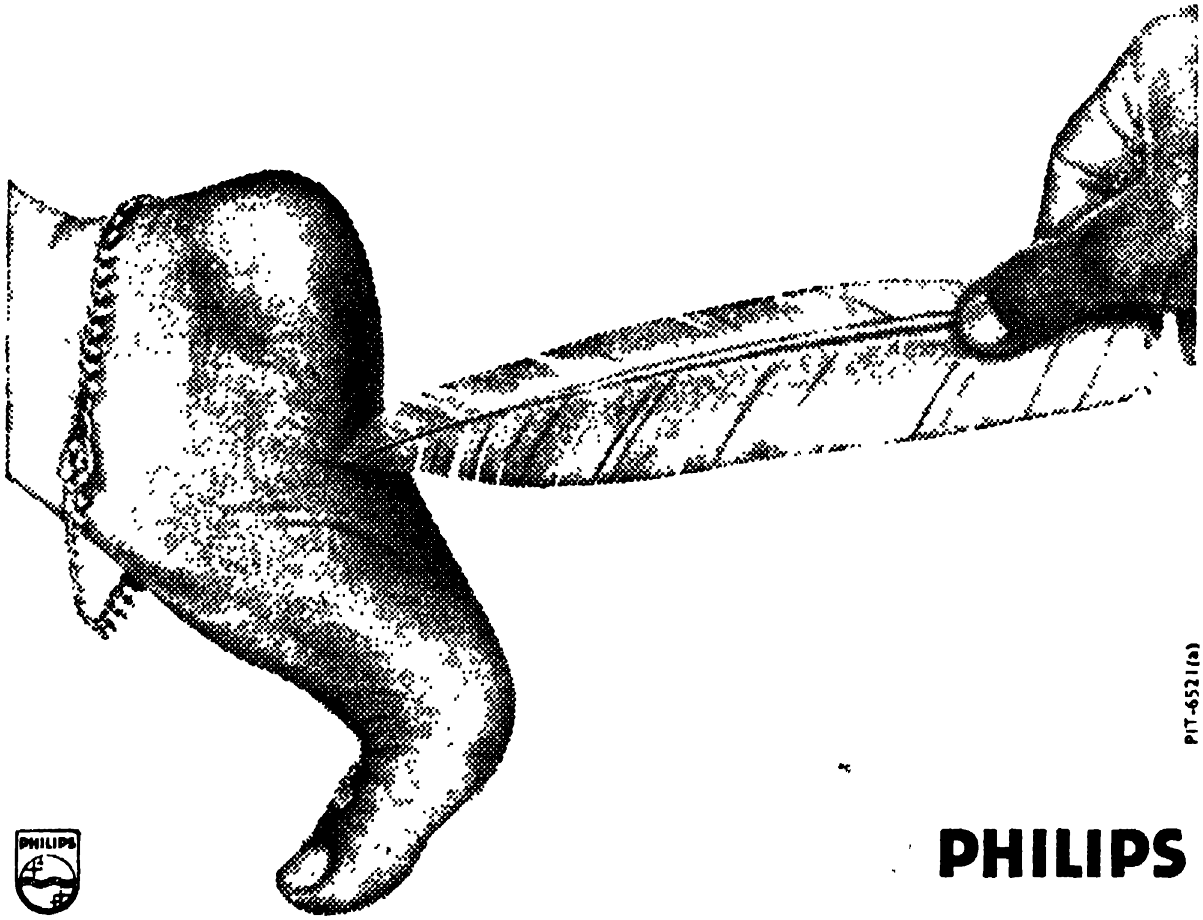

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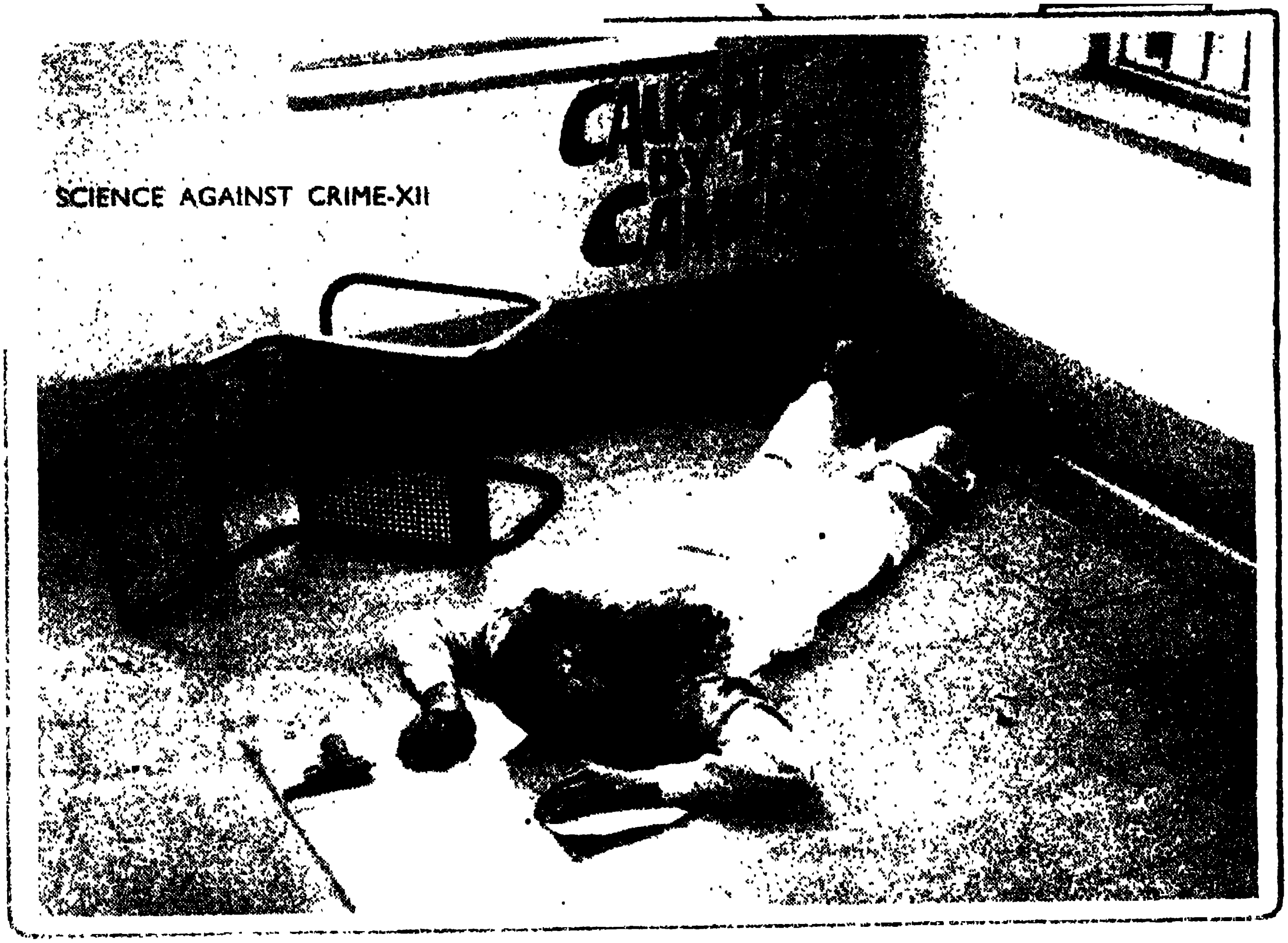
PHILIPS

SCIENCE AGAINST CRIME-XII



A typical murder scene made to look like suicide. But the position of the gun and the empty cartridge case, and the arrangement and relative positions of other objects, helped rule out the suicide theory

One of the first persons to reach the scene of a violent crime is the police photographer. Working swiftly, he records forever a scene which may throw light upon the who, what or why of the crime. In the laboratory he employs a range of techniques to show up clues that the naked eye might miss

P. N. MEHRA

A **GOOD** photograph is worth a thousand words because it is a good reproduction of what the eye sees. Often it provides the answers to the crime investigator's questions "Who? What? Where? When? and Why?" Hence photography has become well-nigh indispensable in crime investigation. In the following case the camera all but saved a man from the gallows.

They were a young couple displaced from West Pakistan, living near Allahabad cantonment. The husband was a dandy and neglected his wife, who in turn developed a nagging habit. The two were always quarrelling over petty matters. Late one evening, a shot was heard from their tenement and the neighbours found the woman lying in a pool of blood. Near her feet lay a gun.

The police on reaching the spot immediately photographed the crime scene from various angles. The gun was a double-barrel gun licensed in the name of the woman's husband. The latter pleaded that he was away from the house at the time his wife was killed, but none of the neighbours were prepared to corroborate his alibi and he was remanded to custody. All the evidence went against him. But when the photographs of the crime scene were developed, the following facts came to light:

(1) The woman had been shot in the middle of the bosom, a little on the right hand side. (2) The wound, almost the size of a rat-hole, was on the naked body where the clothes had been ripped apart. (3) The left barrel of the gun had been fired and the safety catch was removed. The gun was lying on her right side near the feet. (4) There was a perceptible impression left by the butt of the gun, on the kutcha floor of the hut. (5) Near the left hand of the victim a steel rod was found.

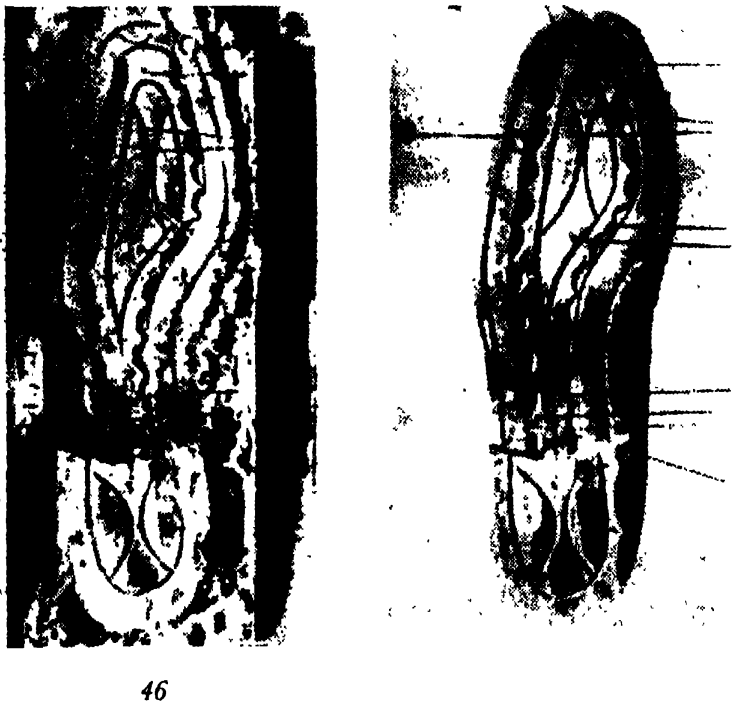
A careful examination of these photographs helped reconstruct the crime. The woman had evidently killed herself by leaning over the gun, kept at an angle, and firing it with the help of the steel rod; being only five feet tall she could not reach the trigger. The depression mark of the butt-end near her feet, the fact that she was a left-hander and the fact that the safety catch had been removed and the presence of the steel rod on her left side, proved that this was a case of suicide and not homicide. But for this reconstruction of the scene of crime from the photographs, the inference would have been 'homicide', especially in view of the relations between the couple.

With the spread of scientific methodology the investigation of crime has come to depend on the indirect or what is commonly called 'circumstantial' evidence, which is objective. The direct evidence, which is popularly known as *chashm-dida-gawah* in our country, has been more or less discarded because of its subjective nature. The indirect evidence depends a good deal on the science of photography to record the scene of crime and also the very many clues which help to link the crime with the criminal.

There are two main applications of photography in crime: *i*) photographing the scene of crime to record the clues present on the spot at the time of occurrence and thereby to preserve them and *ii*) in examining and investigating, by experts of the clues in a forensic laboratory.

The scene of crime has to be photographed before it is disturbed and valuable evidence lost. Deductions can be made from the positions of various objects present on the scene and their

Comparison of the shoe print found at the scene of a burglary and the sole of the shoe worn by the suspect (*right*) linked him with the crime. Individual characteristics like nails and worn-out parts are conclusive evidence

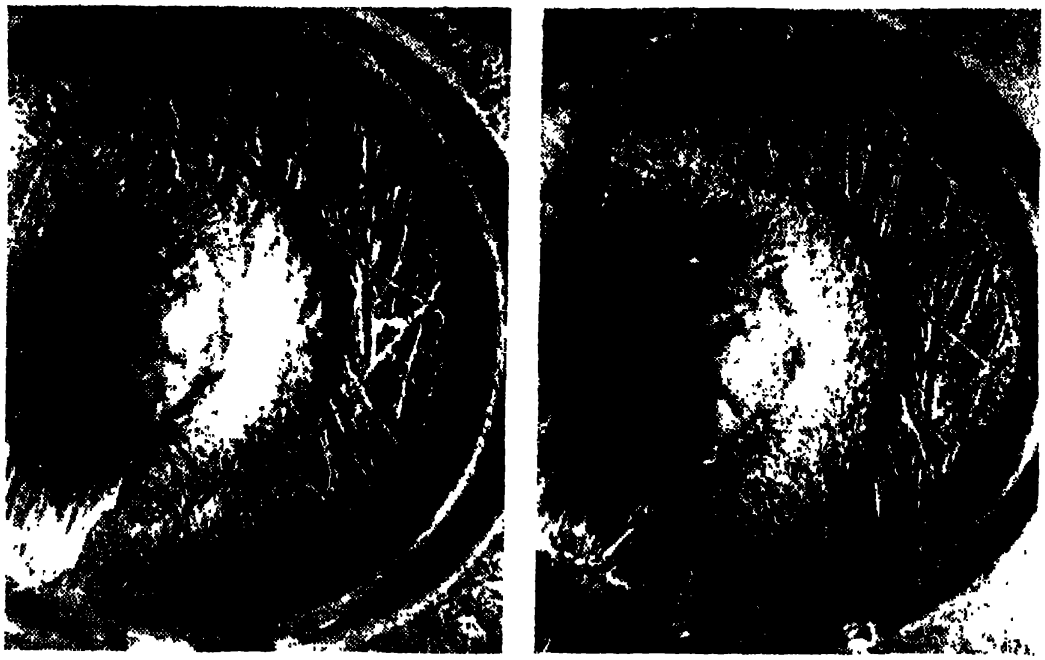


THE CAMERA

MOST people believe that a camera does not lie. They think that all one has to do is to point the camera at the object and while the results may vary in sharpness and focus, they assume the reproduction of the object to be accurate. Actually the reverse is true, and getting an accurate photograph in any type of investigation is most difficult. The distortions can be accidental or deliberate. The distortion can be produced or can accidentally crop up by using various kinds of lighting, lenses, filters, perspective and contrasts.

Lighting is what controls a picture and should normally be from the same direction as the actual illumination of the scene. At least one photograph should be made this way to show the actual lighting of the area as viewed by the eye. Different light positions can then be used to accentuate exact details. To bring out details in the shadow areas, the strongest light is placed on the darkest area; this also helps to emphasise the important physical clues. Similarly, side lighting can be used to bring out indentations on a car involved in a hit-and-run case. These will be lost in direct or diffused light. Using the same techniques in toning, an important clue can be eliminated deliberately. Similarly, a light at an angle of 45° is necessary to obtain the identity of 'mug shots'. Flat lighting gives a one-dimensional photo which eliminates contours of the face, nose size and other facial features. On the other hand, by keeping the light low a ghost-like psychological effect is obtained purposely. Such a picture does not speak the truth and is of no use in police work.

Another distortion common in scene-of-crime photographs is in the relative distances of the objects,



A composite photomicrograph of a cartridge case found at the scene of a crime (*left*) and the test cartridge fired from the suspected gun (*right*) shows identical markings left by striations of the breech block on their bases

relative position to each other. But the scene gets disturbed during the investigation and this makes the photography of the crime scene a necessity.

PHOTOGRAPHY is also used by forensic experts to unearth the invisible clues, or for comparing two small objects not easily seen by the eye. This is done by ultraviolet and infrared photography, photomicrography, photomacrography, etc which call for special techniques (see box on p. 49).

Ultraviolet and infrared photography is used mainly in examining documents. It is virtually impossible, nowadays, to alter, delete, add to, interpolate, erase or eradicate a document in such a way that it cannot be detected. Infrared and ultraviolet light can be used to photograph documents to bring out erasures and show discolorations caused by ink eradicators. Original writing can also be restored by this method if it has been chemically erased.

The basis of forensic science is that no two objects or impressions are absolutely alike unless they come from the same source. All objects can be identified by their individual characteristics. The fact is used in identifying hair, fibres, fired catridge cases or bullets. For this purpose the objects are photographed through the microscope. These " photomicrographs " of the questioned, and the sample, objects can easily point out the differences or similarities in the questioned object and the sample.

Magnified photos of objects are also produced without the use of microscopes. This is done by photographing the object through extension tubes or bellows or, in some cases, close-up

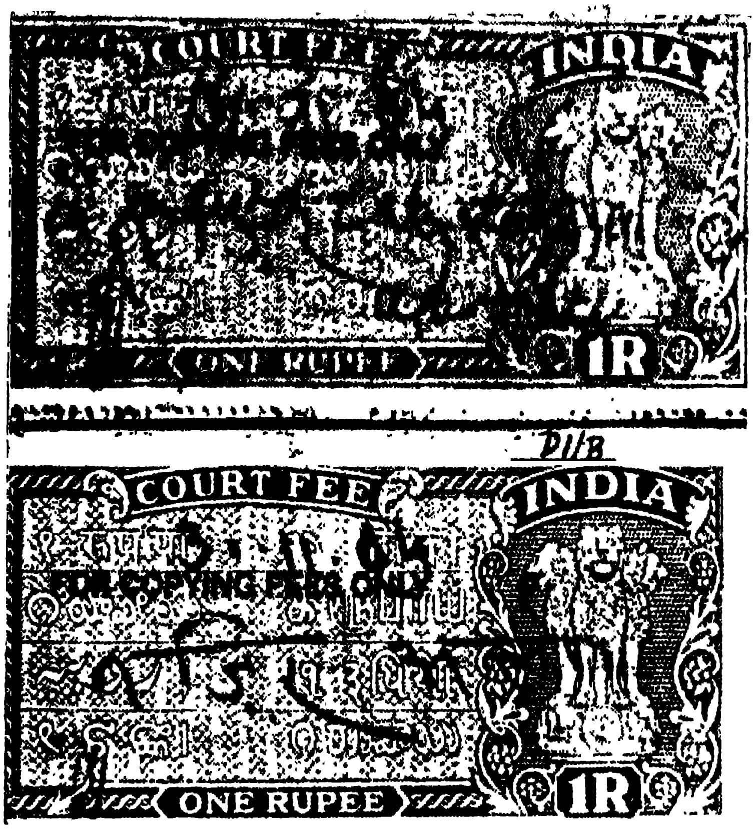
DOES NOT LIE, EH?

To avoid this, the normal lens on the camera should have a focal length equal to the diagonal of the film (frame or negative). The angle of view of a normal lens varies between 43 to 53 degrees as compared to the 30° selective view of the eye. A wide-angle lens, often used to cover the whole scene where distances are small, has a 90 to 100° field of view. But its ability to cover a greater area gives an extreme and thus incorrect illusion of depth. It makes the background retreat away from the subject. Similarly, a telephoto lens gives a wrong idea of depth by foreshortening the distances between objects. But this lens is useful for photographing small areas inaccessible with normal lens.

Camera position also helps to distort distances. A low camera position gives an idea of greater distance while a very high camera position shortens it. The ideal position for shooting a scene of crime is eye level, i e about five feet. This is useful in recording skid marks or tyre tracks in a car accident. Printing density can help to distort the colour values of the objects in a scene. The distortions can also be produced by retouching the negative which is an inhibition in forensic work.

Since film is more sensitive to certain colours than the eye, it is necessary to use filters to obtain an exact reproduction of the grey values in a scene. A filter lightens its own colour and darkens its complementary colours. By using a red filter a blood clot can be eliminated. Similarly, coloured objects can also be eliminated or writing or letterings on signs can be removed. A judicious use of filters should be made.

P.N.M.



Infrared photograph (*top*) showed how the writing on the court fee stamp had been erased and changed. A different kind of ink used to make the alteration aroused suspicion. It is almost impossible to match inks in such a way that they will not show under infrared light. Infrared photography also helps in deciphering burnt and charred documents

lenses. It is used in all cases where the area to be photographed is comparatively large, such as broken ends of instruments, to establish by means of physical fits that these are parts of the same whole. It can also be used in connecting handwriting or type-written matter with a person or a machine. This is photomacrography.

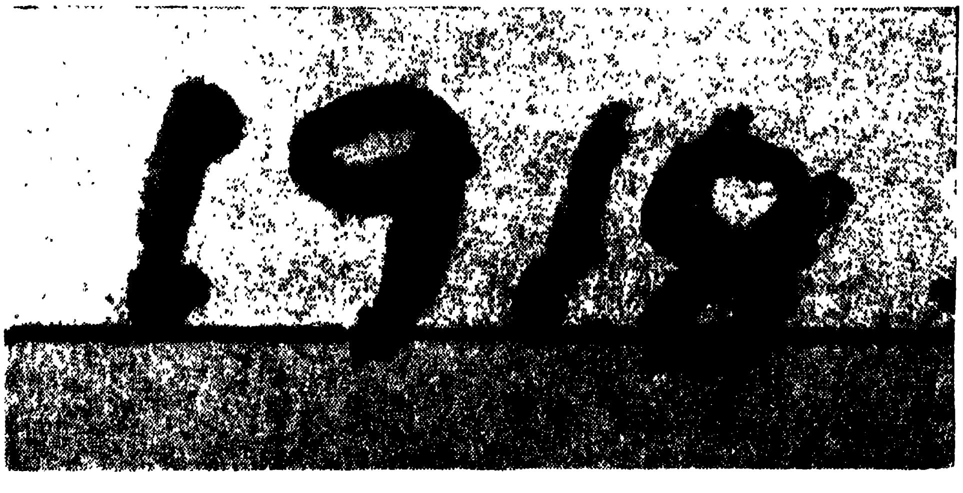
Photography of finger and footprints

AS SOON AS A latent fingerprint is found at the scene of crime it is photographed to fix its position. This is necessary again when the print has been developed by dusting powders. This is done to preserve the prints which are often ruined in handling or improperly lifted with scotch tape or patch. A fingerprint is an irrefutable signature of the criminal, and therefore has to be very carefully preserved, to prevent claims and counter-claims. The infinite small ridges on the papillary surface are individual to an impression and thus constitute means of positive identification.

X-ray photographs are used for detecting concealed and dangerous weapons and bombs, especially the ones sent in the mail; this can be done without opening the covers. Oblique light photographs are made to decipher indented writings and writings on carbon papers. Normally, when the top sheet of a pad is torn off after writing and destroyed, the indentations on the page below or on any other smooth surface can be restored by using an oblique light. This also helps in bringing up marks not easily visible. In a murder case the dead body was transported in the trunk of a car. Eight witnesses who saw the body were unable to see any unusual marks on the thighs. A photograph made by using side lighting clearly brought out the impression of the tyre rim on which the body had rested.

Another area in which photography is being used successfully is in the identification of a miss-

Magnified photograph of part of a certificate where the date of birth was changed from 1914 to 1918. The alteration could not be seen with the naked eye in the original (See also "Foiling the Forger", *Science Today*, Feb 1973, p. 54)



ing person when only a skull is found. This is strictly speaking the job of an anatomist, but the technique involved is purely photographic. Translucent enlargements of the head of the suspected victim's photograph are superimposed on a magnified photograph of the skull. If the cavities and bumps are similar, the identity is established. This technique was first used in the celebrated Ruxton case in the UK.

In the last decade, colour photography has made rapid strides and it is now possible to obtain colour photographs in almost the same colours as the object photographed. Colour photographs, besides giving a better perspective of special relationship, eliminate speculation among the witnesses as to the colour of the defendant's pants or the driver's shirt. It is very effective in cases where colour is an element of the crime. In a case involving a butcher who was mixing stale meat with fresh, colour photographs clearly showed the distinction between the bluish tinge of the stale meat and the pinkish hue of the fresh.

Where movement is important, motion pictures are an invaluable means of preserving evidence. This is mostly being used in counter-espionage, cases of bribery and occasionally in divorce cases. The persuasive impact of motion pictures of the suspect which not only shows his actions but also fine nuances of mood and emotion often tell a complete story. It is being used with very good results in cases involving intoxicated drivers. Different people react differently to alcohol and almost every one of them claims to be in control of his senses. They are asked to walk on a marked straight line and a motion picture is made; or they can be asked to go up a flight of stairs and then write on a black board. Their uncertain movements are shown to them in the film when they are in a sober state. In almost all cases so dealt with, there is no room for speculation or counter-claims. Motion pictures are also used in riots and surveillance and in identifying a person through his habits of gait and body movements which are much more difficult to disguise than facial or physical features.

Many and varied are the uses of photography in crime detection and the limit to its application depends entirely on the realisation of its potentialities by the forensic scientists on the one hand and the investigation experts on the other.

[Mr. P. N. Mehra is Assistant Director (Photography) at the Institute of Criminology and Forensic Science, New Delhi, where he teaches police photography. He is President of the Federation of Indian Photographers.]

Photomacrograph of a *bidi* label found at a crime scene (*top*) showing exact physical fit with the other part recovered from a bundle in the suspect's possession. Such torn fragments are often found in hit-and-run cases

Larger than Life

PHOTOMICROGRAPHY can be used in investigating forgeries of paintings and postal stamps, for the forger inevitably uses different kinds of ink, which transmit light in different amounts, depending upon their chemical composition. The philatelist can investigate not only colour differences and repairs, but differences in paper and gum by means of oblique surface illumination. Postmarks which have been chemically removed can be detected by choosing a filter of the same colour as the stamp, so that the stamp will appear in the finished photograph practically white, while the impression of the postmark will appear dark.

Low power photomicrography can be done without a microscope. The simplest approach is to use an ordinary camera fitted with a supplementary lens: the latter can be improvised with an ordinary spectacle lens fitted into a cardboard mount over the camera lens. If the camera lens is focused at infinity and the supplementary lens is fitted closely in front of it, then an object placed at a distance equal to the focal length of the supplementary lens will be sharply focused on the film or screen.

Similar results can be obtained by using a magnifying glass removed from its holder and mounted in a cardboard tube by means of cardboard rings. As these lenses are not corrected, only the centre of the field should be used.

NEXT MONTH:

INVESTIGATION OF SEX OFFENCES

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to different people
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ideas & inventions

Valve-grinding Done in a Jiffy

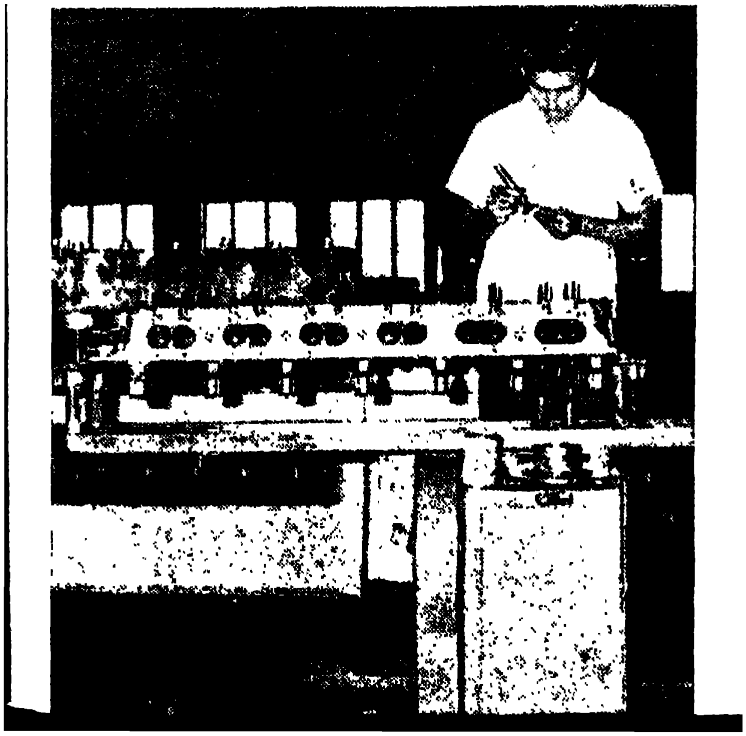
A **MACHINE** virtually rigged up from junk lying in the scrapyard of the Oil and Natural Gas Commission's Central Workshop at Baroda is doing a fine job 'lapping' valves and valve seats on internal combustion engines: it does in ten minutes what six persons used to do in eight hours!

Lapping, or grinding of valves and valve seats to a fine finish, is an unavoidable process in capital repair or manufacture of diesel engines. Only manual valve lapping was hitherto known in this country. Mr. S. M. Chauhan, diesel mechanic at the Baroda workshop, found this too monotonous and slow. He had an idea, which clicked. The scrapyard provided the materials. The head workshop assistant, Mr. G. M. Dave, encouraged him and after three months of relentless work a prototype that worked was born.

The machine is an ingenious combination of timing gears, rack and pinion, and camshaft followers. This is how it works. A half horsepower motor drives a pair of V-grooved pulleys, one of which is a speed reducing pulley that drives a set of four spur and bevel gears. One of these spur gears is so connected to a crank wheel that it gives reciprocating motion to a rack, which engages a pinion and gives it a semi-rotary motion. This pinion, in turn, drives a set of four gears which can be connected to the four valves to be lapped through flexible joints, thus imparting its semi-rotary motion to the valves. Up and down motion of the valves is achieved by one of the first set of bevel gears rotating, through a bevel gear/spur gear arrangement, and two camshafts located beneath the valve lappets. Helical springs provide the necessary pressure on the valves.

The quality of work turned out by the machine is good and of uniform standard, unlike in manual operation where the skill of the mechanic matters a great deal.

. . . uniform work of good quality



A Slide Rule for Canal Designers

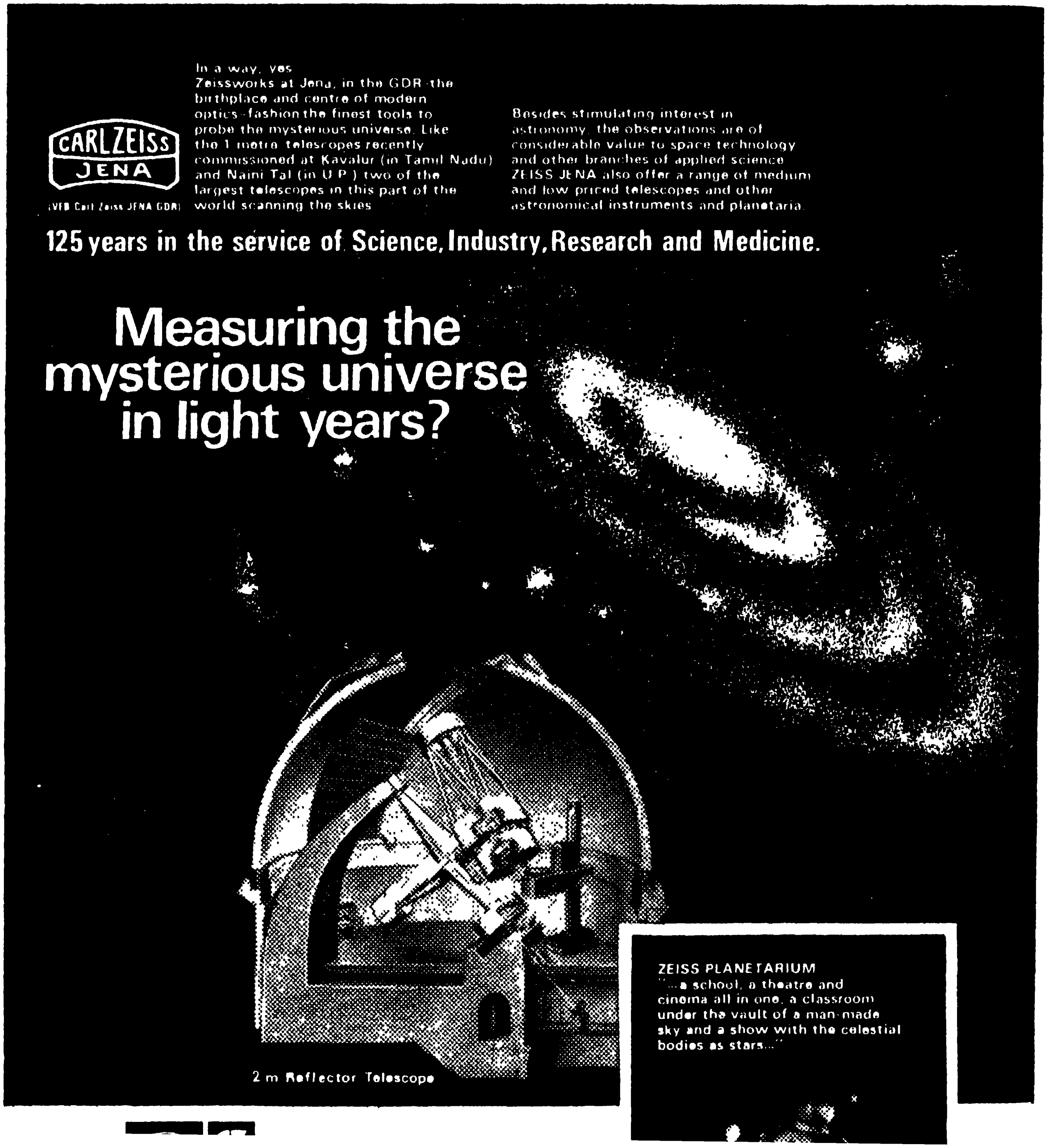
ENGINEERS need no longer depend on charts and graphs for designing falls and regulators on canals over permeable foundations. A slide rule invented by Mr. R. R. Dutta of Calcutta enables direct determination of all sets of values of total floor length, level and length of crest, depth of piles, pavement thickness, and so on.

The instrument has two parallel fixed bars about 32 mm apart and having square recessed grooves inside to accommodate a 39 mm wide slider in between. Both the fixed bar and the slider have scales marked on them, the latter on both faces. A 51 × 39 mm size transparent plastic cursor having metallic rails at the edges, fitted inside inset grooves on the fixed bars, glides over these scales; it has a line mark at right angles to the run of the scales. On the extreme right of the sliding piece is a set of scales where the information is recorded and then delivered on to an information board.

The scales on the instrument, according to Mr. Dutta, are based on entirely new parameters of fundamental relationships connected with seepage theory. The slide rule is so designed that you can easily determine an unknown parameter by simply adjusting the known parameters and sliding the cursor over the scales.

Mr. Dutta has already supplied a number of his slide rules to various universities, engineering institutions, electricity boards and design organisations.

Badiuddin Khan



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NEW RAILWAY WARNING SYSTEM

When the Driver Fails, this Won't!

EARLY in June this year, an electric train rammed into another stationary train at Malad, a Bombay suburban station, killing 15 persons. Within a few days, another accident occurred near Vikhroli, another Bombay suburban station. Fortunately, this time there were no serious casualties. Preliminary inquiries into both accidents have shown that the engine driver had ignored the signals.

Answering questions in Parliament later in July, Mr. Mohd. Shafi Qureshi, Deputy Railway Minister, said publicity campaigns should be conducted to educate the public since human failures other than those by the railway staff were also responsible for a number of accidents. Mr. Qureshi was probably referring to the accidents and collisions at level crossings which are normally due to the carelessness of the public.

Yet the fact remains that failure of railway staff is still a major factor in railway accidents. Only one out of the 57 collisions during 1971-72 was due to the failure of " other than railway staff ", according to the Directorate of Safety of the Railway Board. Fifty-four were caused by the failure of the railway staff and the other two were accidental.

Maybe, sometimes the signals are faulty. But more often, it is the engine driver who is at fault, either too careless to follow the traffic signals or too fatigued to respond to them. A study of the 18 cases of major accidents during 1971-72 by the Commissioner of Railway Safety is revealing. Of these, three were caused by driving trains " past station fixed signals at danger ", and two were due to " trains driven without requisite care in the automatic signalling section after or without stopping at signal displaying red ".

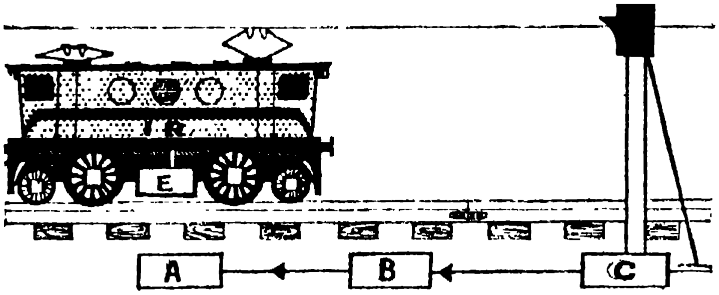
The only available check against such incidents is the driver's vigilance device. It is an electropneumatic or electronic device fitted in the driving cab of the locomotives. The driver has to actuate the device every 40 seconds or so, either through a push button or a foot-pedal. If he fails to do so, there is a warning sound in the cab, and if this is ignored, the brakes are applied automatically.

The Commissioner of Railway Safety had recommended that all locomotives should be equipped with this vigilance device, particularly diesel and electric locomotives, where conditions are likely to induce sleep in the driver. Even at best, this is only a vigilance device and not a preventive measure; it only ensures that the driver is vigilant but as long as the driver keeps actuating the system regularly, there is nothing to prevent him from driving past a danger signal. What is worse, while the Railway Board had accepted the recommendation, the Commissioner of Railway Safety says in his report that " regrettably the pace of its implementation has been slow ".

Inquiries into serious accidents during the last five years, the report says, have shown that either the device had not been fitted, or where fitted, poorly maintained. The report draws the Railway Board's attention to this serious lapse.

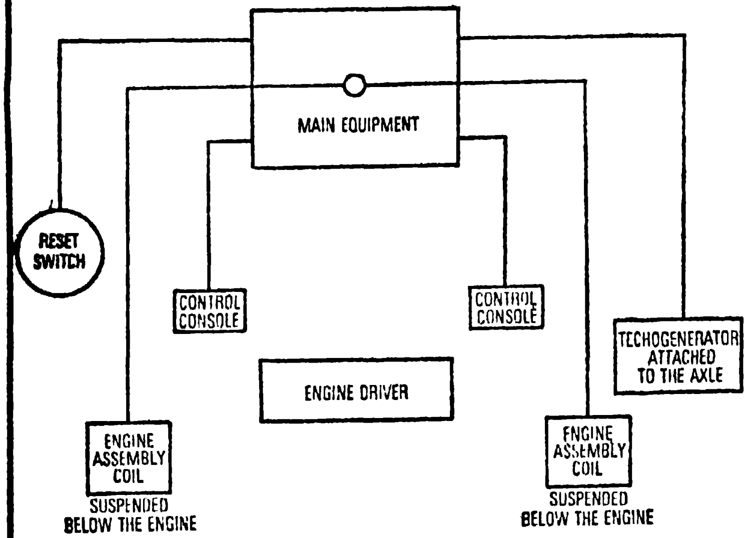
TO ELIMINATE human error, the device should not only warn the driver but also take preventive action by itself if he fails to do so. Such automatic train warning systems are used in other countries, particularly in the Netherlands (SCIENCE TODAY, October 1966) and Japan where the New Togado line runs at a speed of 230 km/hour. Railway traffic in India will increase in the next few years; besides, the railways are planning to raise the speed from the present 130 km/hour to about 200 km/hour on some of the main routes. This would obviously necessitate a fool-proof warning system.

Indeed such a device, based on imported components, is being introduced on the 685-km Grand Chord route between Howrah and



A B AND C are the track coil assemblies for the outer signal posts. Point C is used only in the automatic signalling region. Now when the signal shows red or danger, as soon as the locomotive passes point A, the blue lamp in the control console switches itself 'off' and the white lamp comes 'on'. And at the same time, the hooter begins to sound. This warning sound continues for seven seconds within which the driver should acknowledge the warning by pressing a button. The hooter continues to sound for another five seconds after the acknowledgment to warn the driver that he should apply the brakes. If the driver fails to acknowledge the warning, the system applies the brake automatically. So also, if the driver keeps the acknowledgment button pressed continuously for more than three seconds to mislead the system, it will apply the brakes automatically.

Automatic warning system



Control console

When the train approaches the track assembly at B, the electronic data processing (EDP) equipment in the cabin automatically compares the speed of the train with a safe reference speed limit (depending on the original speed of the train and other factors like gradient, etc). This information on the train speed is continuously fed to the EDP equipment through a techogenerator attached to the axle of the wheel. If the speed of the train at point B exceeds the safe speed limit, the system again applies a faster brake and the train comes to a halt before the signal post.

Once the AWS applies the brakes, the driver has no control over the train. To start the train again after it has come to a halt, the driver has to use a reset switch which is provided at an inconvenient position. This gives a time gap. Generally the switch is provided away from the engine so that the driver has to get off the engine to operate it.

In the automatic signalling regions like Bombay, Delhi, Calcutta and Madras, the driver is allowed to cross the danger signal after halting for a short time (a minute during day and two minutes during night) and proceed slowly at 15 km/hour to the next signal post. When the train crosses point C at red signal, this fact is recorded. Thereafter, until he reaches the next signal, the hooter warns the driver whenever he exceeds the speed limit. The red light on the console will stay on to remind him of the danger until he passes the next "clear" signal.

To provide manoeuvrability, the engine coil assembly (E) is provided on either side of the engine and so also the control console. The track assembly is electrically connected to the electrical signalling system, and in the semaphor-type lever signalling system, the cabin lever is coupled to the track assembly through switches and relays.

V. K. Menon

[Menon is with Electronics Division, Bhabha Atomic Research Centre, Trombay.]

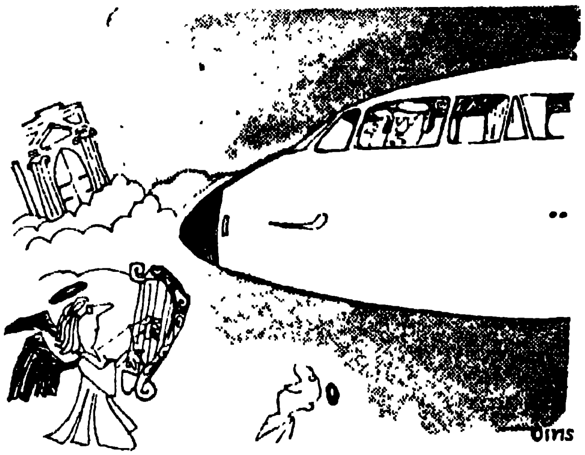
Mogulsarai on the Eastern Railway. Now the Research and Designs Organisation of the Railways (RDSO), Lucknow, and the Bhabha Atomic Research Centre at Trombay are jointly working on an indigenous electronic automatic warning system (AWS).

The system works on the basis of inductive interaction between two tuned circuits — the track coil assembly (placed along the track and controlled from the signal cabin) and the engine coil assembly, suspended below the engine and controlled from an electronic data processing equipment in the driver's cabin. The track coil assembly picks up the signals along the tracks and when the engine coil assembly passes over it, induces appropriate electrical impulses in the engine coil assembly. These impulses are then transmitted to the data proessing equipment in the cabin where they are converted into a system of audio-visual warning on a control console (see box). For instance, if the signal is green, a bell rings continuously in the cabin. If it is red, a hooter will warn the driver. If the driver fails to stop the train, the system will automatically apply the brakes and bring the train to a halt. Every instance of such automatic braking will be noted by a recorder so the driver could be questioned later. The system thus has four channels — one each for red signal, green signal, speed check and speed control.

So far the system has been tried out under simulated conditions. It is claimed that the system has been designed for speeds upto 200 km/hour. Since weather conditions in the country vary widely, the system has also been designed to operate between — 25 °C and 85 °C, and also under voltage fluctuations from — 40 per cent to + 25 per cent of the nominal operating voltage.

Yet one question remains. What if the signal itself is faulty? In the automatic signalling regions, signalling is based on the fail-safe system; it will show 'red' or danger if the signalling system fails, and so naturally the AWS will also repeat the signal. In areas of semaphore lever signals, the AWS will not be of help if the signals themselves are wrong.

K. P. N.



"Are you sure the altimeter reading is only 10,000 metres ?"

awards and appointments

● The **Shanti Swarup Bhatnagar Prize** for 1970 has been awarded to two scientists. Dr. P. T. Narasimhan, professor of chemistry, Indian Institute of Technology, Kanpur, and Dr. J. R. Talwar, assistant professor of cardiotherapic surgery, All India Institute of Medical Sciences, New Delhi, share the Rs. 10,000 prize.

The Bhatnagar Prize for 1971 has been shared by seven scientists: Dr. A. Bhattacharya, professor of mechanical engineering, Jadavpur University; M. M. Dhar, scientist with the Central Drug Research Institute, Lucknow; Dr. O. D. Gulati, professor of pharmacology, Medical College, Baroda; Dr. P. K. Iyengar, head of the nuclear physics division, Bhabha Atomic Research Centre; Prof. M. S. Kanungo, zoology department, Banaras Hindu University; Dr. A. K. Maiti, reader in physiology and also head of the biochemistry and biophysics department at the University Medical College, Calcutta; and Prof. N. B. Nair, marine biology and fisheries, University of Kerala.

● Dr. C. N. R. Rao, professor of chemistry, Indian Institute of Technology, Kanpur, has been awarded the **Jawaharlal Nehru Fellowship** this year. Dr. Rao also heads the education development centre. He plans to study science education problems and educational technology with reference to India.

● The **Kalinga Prize** goes to Nigel Calder, ex-editor of *New Scientist*. The British journalist has also written several scientific books. His father, Lord Ritchie Calder was awarded the same prize 13 years back in 1960. Another recipient of the Kalinga Prize is Dr. Philip Abelson, an American, and editor of *Science*.

● The **Metallurgists of the Year Award** goes to six eminent metallurgists. They are Mr. K. K. Cherian (non-ferrous metals technology), Mr. S. L. Malhotra (pilot plant research), Mr. B. V. Prabhu (heavy foundry technology), Dr. P. Rama Rao (education and fundamental research), Mr. E. R. C. Shekar (iron and steel technology), and Mr. V. R. Subramaniam (welding technology).

● Dr. C. Gopalan has been appointed Director-General of the Indian Council of Medical Research. He was formerly director of the National Institute of Nutrition, Hyderabad.

● Dr. Raja Ramanna, Director of the Bhabha Atomic Research Centre, Trombay, has been appointed Chairman of Bharat Electronics Limited, Bangalore.

● Dr. V. Ramalingaswamy, Director, All-India Institute of Medical Sciences, New Delhi, has been elected Fellow of the US National Academy of Sciences.

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A Housewife's Guide to Oils & Fats

D. REBELLO

Are you fond of "pakodas" and "bhajias" simmering in large pans of hot oil in roadside shops? Do you carry over the remnant of the day's cooking oil to the next day? Did you know both can harm your body?

WHAT oil do you use for your everyday cooking? Groundnut? Til (sesame)? Coconut? Mustard? Or do you go for ghee? Or vanaspati? Perhaps, at the moment, you don't really have much choice. But, did you know, in terms of food value, they are all the same? One gram of any of these will give you 9·3 Calories of energy. And that's a lot, when compared to proteins and carbohydrates, which give just 4 Calories per gram. Yet you hear of some oils being good, while others are positively dangerous. The last issue of SCIENCE TODAY carried a detailed discussion on the chemistry and properties of fats and oils. Here are some down-to-earth tips for the housewife in her kitchen.

Fats and oils are essentially the same; the only difference is fats are solid and oils are liquid. How do you purchase your cooking oil? Loose, from out of open containers, or in sealed tins? Remember, when you buy a sealed container, you pay extra for the container, but then you get protection. Many an oil, seemingly pure, is adulterated. If the adulterant is a cheaper oil, this may not be particularly harmful; but the adulterant could also be a harmful oil, such as argemone oil or just plain, indigestible mineral oil.

What about *ghani* oils, usually sold raw, i e unrefined and loose? These are prized for their natural flavours which come from the minor non-fat constituents present in these. These also contain desirable substances such as phospholipids and vitamins and their precursors such as carotenes. Phospholipids can however be troublesome because of the frothing they cause in the frying pan. But raw oils are not quite stable, since they contain free fatty acids and often moisture, both of which promote rancidity. Naturally, the market variety has to be refined and sold sealed for longer storage.

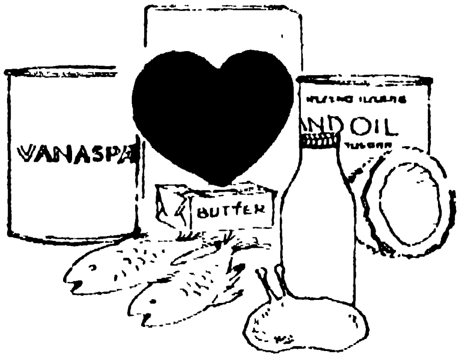
Refined oils are bland and have little or no odour. Why, then do we get the unpleasant odour from an old closed empty oil tin? The reason: the thin layer of oil in the tin has gone rancid, after being attacked by the oxygen in the air. This oxidative rancidity is a continuous process and occurs in all oils. It is hastened by light, heat, moisture and free fatty acids. Refined oils are therefore packed dry, in sealed tins, usually under vacuum, with little air.

OXIDATION products of oils are present not only in badly stored oils, but also in overheated oils, like the ones you get during shallow pan- or deep-frying. Those tempting *pakodas*, *bhajias* and *samosas*, simmering in large pans of hot oil in roadside shops are rich in these oxidised products. Many a housewife has the habit of carrying over the remnant of the day's cooking oil to the next day and replenishing it with more oil. Remember, during the overnight storage, the oil continues to get oxidised and these oxidation products multiply during the next day's frying and get carried over into the fried food. It is much better to use a little oil and start with a clean frying pan each day. Gentle simmering, however, has less chance of oxidation, and if the food item is fairly wet, the steam acts as a protective layer against oxygen during the heating.

What makes the oxidation products harmful? Well, for one thing, these get concentrated in the liver and deplete the fat-soluble vitamins, A and D. Again, oxidised fats also interfere with certain enzyme functions involved in the oxidation-reduction mechanisms in the body. Recent researches have also indicated that overheated or otherwise oxidised fats could be carcinogenic, i e cancer-causing. Oxidation also destroys the very important and essential constituent of natural fats, namely, the polyunsaturated fatty acid (PUFA)— linoleic acid. Of course certain preservatives, called antioxidants, can reduce oxidation. These substances are present in some natural vegetable oils; however, in most cases, synthetic antioxidants must be added to the refined oils, as they are done these days (it is indicated on the container).

Oxidative spoilage is less (whether in the tin or in the frying pan) with solid fats like ghee or vanaspati (which is nothing but vegetable oil converted into a solid product — melting at body temperature — by a process known as hydrogenation). It is enriched with Vitamins A and D. These fats do not contain much of the easily oxidised PUFA and so are more stable in the frying pan. Food items cooked in these solid fats are more crisp and tastier than with oils. Why? The reason is more moisture can get in through the liquid oil film than through the solid fat film surrounding the cooked item. Like in the rainy season, food items feel softer.

Fats and the heart



FATS are hydrolysed in the body to fatty acids which are further broken down to acetate, which is used for building up cholesterol. Saturated short chain and unsaturated fatty acids are broken down more readily than saturated long chain acids. Therefore solid fats are less digestible than liquid oils. Though cholesterol is portrayed as a substance to be got rid of, it is absolutely essential for growth since this gives rise to the steroid hormones and bile acids.

Cholesterol is absorbed through the intestine in the free state and is present in the blood plasma in the free and esterified form. When the blood cholesterol level goes high, there is an accumulation of lipids (cholesterol esters phospholipids and free cholesterol) on the inner walls of arteries, a condition known as atherosclerosis. The artery wall gets locally thickened and loses elasticity; blood-flow through the artery is slowed down because of the constriction. When a blood clot (thrombus) — usually at the site of the atherosclerotic lesion — stops the flow of blood through the heart, the heart tissue degenerates and in extreme cases leads to heart failure.

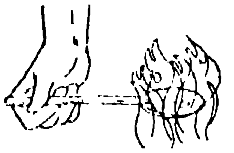
People prone to heart attack or whose blood cholesterol levels are high, would do well to avoid solid or saturated fats such as coconut, ghee or vanaspati and to switch over to liquid oils, such as sesame or safflower.

You may have wondered why vanaspati these days is becoming more colourful. In the days of plenty, groundnut oil was the main source of vanaspati. Slowly cottonseed oil made inroads into groundnut's domain and added a slight yellowish red hue to the product. Today, almost any edible oil, local or imported, such as soyabean, sunflower, palm, rapeseed, etc, finds its way into vanaspati.

HYDROGENATION, like oxidation, destroys the essential fatty acid, linoleic acid, though in a different way. Why all this attention on linoleic acid? It is essential for the body's growth and well-being and its absence in the diet leads to a number of deficiencies, such as decreased body weight, poor skin texture, malfunctions of the kidney, liver and blood circulation, impaired reproduction and lactation, and gives rise to changes in cholesterol metabolism. While the body does synthesise many fatty acids, this is one fatty acid which it does not synthesise and has to be obtained from plant sources. This fatty acid is reported to reduce the cholesterol level of the blood and consequently to reduce the risk of a heart attack. It is also the precursor of prostaglandins, those powerful substances which in a few billionths of a gram significantly affect the well-being of the individual.

Liquid oils, such as safflower, niger, sunflower, sesame, groundnut, cottonseed, mustard and rapeseed contain fairly good amounts of the essential linoleic acid, the first two containing approximately 75 per cent, the others between 15 and 60 per cent. Since linoleic acid is largely destroyed during hydrogenation, the addition of 2·5 per cent safflower oil to vanaspati is made mandatory. This is in addition tc 5 per cent sesame oil (30 per cent linoleic acid), which serves as a test for finding out if vanaspati has been added as an adulterant to ghee. (For detection test — see SCIENCE TODAY, January 1973, " Women and Home ", and November 1973, p. 41.)

So if you want to retain your school-girl complexion, reduce the risk of a heart attack and otherwise improve your well-being and longevity, go for PUFA. A word of caution though: the larger the amount of PUFA in a fat, the greater the risk of oxidative destruction. Don't lose the good-hearted protective value of your safflower oil by placing it in the frying pan or by storing it long in a poor container. What about sesame (til) oil? It is safer, since it has just the right amount of linoleic acid (35 to 50 per cent) and also contains a natural anti-oxidant. You can get it with its natural flavour or flavour-free. Now, if you have to fry anything, like an egg, why not use a solid fat — this has little linoleic acid to lose. Save your safflower or sesame oil for salads or chappati-spread or for preparations involving little heating such as *dal dhokra* or boiled whole pulses, where the oil is added at a later stage.



Don't contaminate oils and fats with moisture. Use dry containers and spoon. Flame dry if necessary

How do you store your fats? Airtight containers supplied by the manufacturers are quite adequate. However, for your daily. needs, transfer the oil into a smaller, clean, dry, amber-coloured bottle. Fats and oils store better in coloured, rather than in colourless bottles, since light promotes oxidation. Also the less the air space, the better the storage life of the oil. This is especially true for safflower oil, which gets more rancid as the oil level goes down. Even though the oil may not smell or taste bad, the food does not last long and must be consumed soon.

Dr. Rebello is Professor of Oils, Fats and Waxes, Department of chemical technology, Bombay University.

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true or false

IN the middle ages, " Truth lived like a spy in an enemy territory. Today it lives like a guerrilla," said one myth-busting author. Does truth still live like a guerrilla in your mind, fighting superstitions and misconceptions? How many of the following popular beliefs are true?

1. Inbreeding produces degeneracy.
2. If the rope breaks at a hanging, the condemned goes free.
3. A dead body weighs more.
4. Chest hair indicates manliness.

ANSWERS: None is true! Read on:

1. That inbreeding or mating of closely related human beings will produce some kind of degeneracy has been a universal myth. The truth is, biologically, it need not. All that inbreeding does is accentuate peculiarities. I there were some latent strain of abnormality, inbreeding would bring it out, and maybe enhance it.

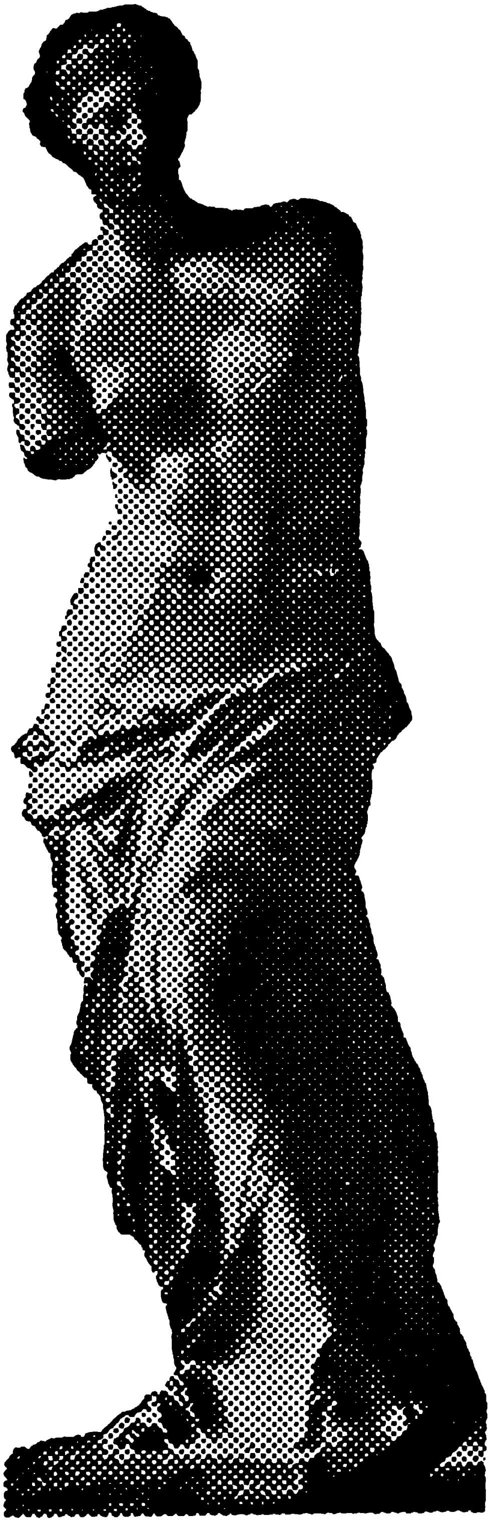
Charles Darwin had married his first cousin, Emma Wedgwood. Their seven children became famous for unusual talents and accomplishments. Cleopatra, who history says was unusually clever and attractive, was the product of six generations of brother-sister marriages.

2. If the rope breaks, the condemned will *not* go free. The misconception may be the result of a misinterpretation of the legal dictum that a man may not be punished twice for the same offence. But in death sentences, it is not the prisoner but the sentence that has to be executed. The sentence always says that the prisoner be hanged *until he be dead.*

3. A dead body only *seems* to weigh more. A living person carries his body about so facilely that he is hardly aware of the enormous weight of his limbs.

4. The belief about chest hair probably originates from references to the gorilla — that a man with hair on his chest resembles a gorilla. Actually, the gorilla has no hair on his chest. On the other hand, some scientists think baldness and not hairiness is the sign of masculinity.

(*More next month*)



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The .On-off Switch for the Lazy Man

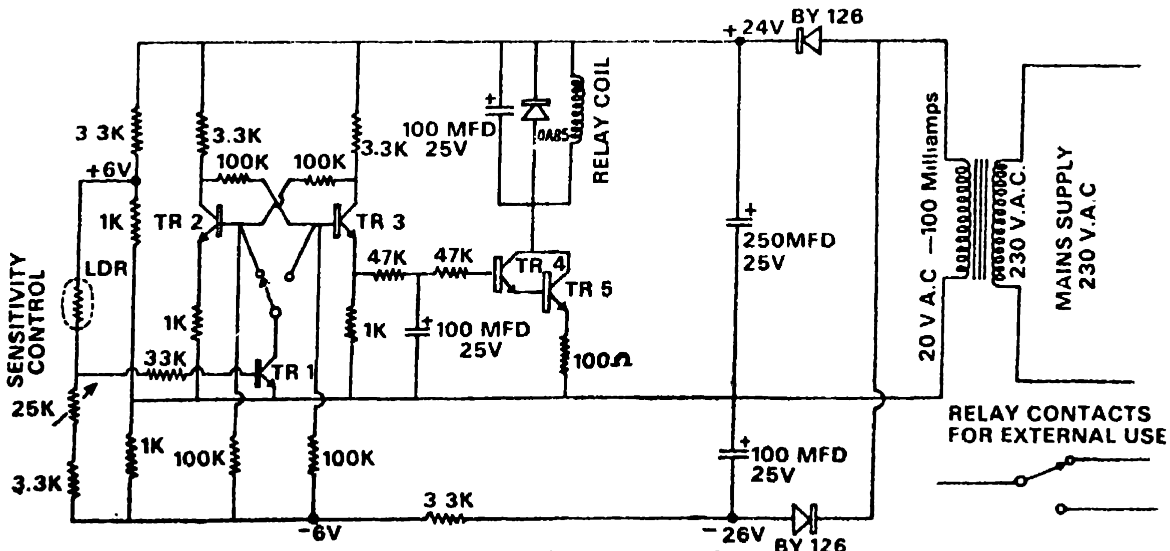
IF you are too lazy to get up from your sofa to switch on or switch off your radio, record player or TV, here is a device that can be actuated with an ordinary torch light. One flash on the device will turn it on, and it will remain on till another flash turns it off. Thus, you can either turn on or turn off anything which works on electricity without getting up and doing it yourself.

The device basically consists of four stages: photoelectric triggering circuit, the bistable multivibrator (flip flop), the Darlington pair amplifier for operating the relay and the necessary positive-negative DC power supplies for all these circuits. Now, to understand the complete operation of the device it is necessary to know the operation of the bistable multivibrator.

The basic electronic circuits in digital computers are multivibrators. Multivibrators are of three types -- astable, monostable and bistable. The operation of the astable multivibrator has been already explained in " Electronic Lamp Flasher" (SCIENCE TODAY, March 1970) and "Audio Signal Injector" (SCIENCE TODAY, Sept. 1972). In this type of multivibrator the current alternately flows first through one transistor and then through the other. Thus, the behaviour is similar to an oscillator.

The bistable multivibrator, as its name suggests, has two stable states, one transistor conducting while the other is at cut-off. This circuit can remain in this condition indefinitely till an external trigger pulse is fed to the conducting transistor to cut-off and forcing the transistor previously at cut-off to become conducting. Again, the bistable multivibrator will remain in this changed condition till it is triggered by one more pulse to the alternate condition.

The transistors Tr2 and Tr3 comprise the bistable multivibrator. The voltage across the emitter resistor of transistor Tr3, when it conducts, is connected to the base of the transistor Tr4 through a resistor capacitor network. The network provides the necessary time delay in operating the relay. The transistors Tr4 and Tr5 comprise the Darlington pair amplifier circuit. The emitter terminal of the transistor Tr4 is directly connected to the base of Tr5. The collectors of both the transistors share a common relay load. These two transistors present only three terminals to the external circuit. The current gain of such a circuit is the product of their individual gains. Since Tr5 is in common leg with Tr4, it will provide negative feedback that will stabilise the gain and the resulting input resistance will be much greater than the single common emitter stage.



ALL THE TRANSISTORS ARE BC 107

When the light flashes on the LDR, the momentary drop in its resistance provides the necessary positive pulse to the base of the transistor Tr1. The transistor thus momentarily becomes conductive and thus triggers the bistable multivibrator to change its state. It is extremely important for proper triggering of the bistable multivibrator that when the relay is in unoperated condition, the collector of the transistor Tr1 should get connected to the base of transistor Tr2 and when the relay is in operated condition it should get connected to the base of the transistor Tr3. This arrangement will automatically keep the collector of transistor Tr1 connected to the base of transistor Tr2 or Tr3, depending upon which is conducting.

The LDR has to be mounted inside a tube having a diameter about 15 mm and length about 100 mm. The tube should be painted with black matt paint. The tube with LDR inside should be placed pointing towards you such that no external light will interfere with the LDR, but whenever you require to actuate the device, you can illuminate the LDR for a second or two with a torch light. The sensitivity control provided on the device is for adjusting the sensitivity of the photoelectric circuit. If the device has to be actuated from a distance you may have to increase its sensitivity.

If the LDR continuously remains illuminated or the sensitivity kept is much more than required the relay will continuously become on and off.

You will need:

Semiconductors: Transistors, BC107 — 5 Nos; Diodes, BY126 — 2 Nos; OA 85 — 1 and LDR—1.

Capacitors: Electrolytic, 100 mfd 25 volts — 3 and 250 mfd 25 volts — 1.

Resistors (all ½ watt): 3·3 K — 5, 100 K — 4, 47 K — 2, 1 K — 4, 33 K — 1 and 100 ohms — 1.

Potentiometer: Carbon 25 K — 1.

Transformer: Mains — Pri: 230 V AC — 1, Sec: 20 V AC — 100 milliamps — 1.

Relay: 24 V DC (resistance of coil 500 ohms or more) with at least 2 changeover contacts.

Misc: Lugstrips or group board, wires, solder, screws, suitable enclosure, knob, etc.

Anil V. Borkar

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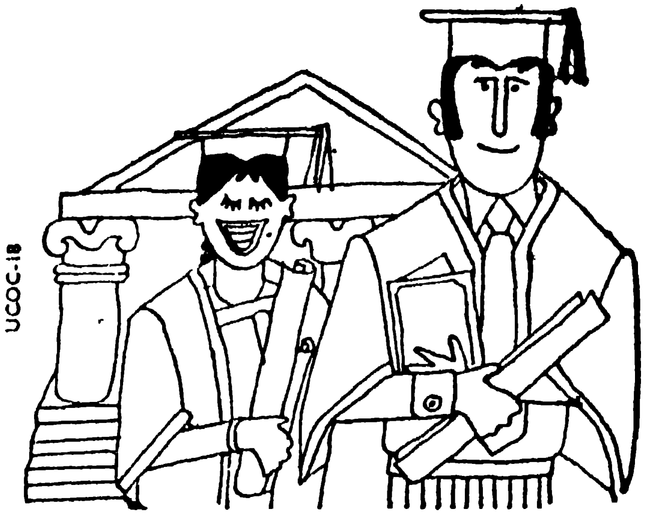

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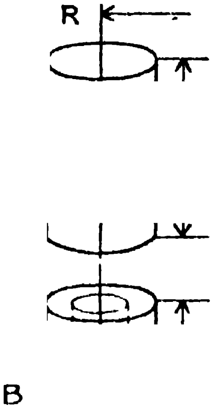
brain teasers



TWO CYLINDERS: Two cylinders A and B, of different materials, are so made that A is solid and B is hollow, but they are equal in all other respects, viz, in external radius, height and mass, too. Both sink in water.

Can you recognise which of the two is solid? (Cutting them open, exposing them to X-rays, etc, and chemical analysis are not allowed.)

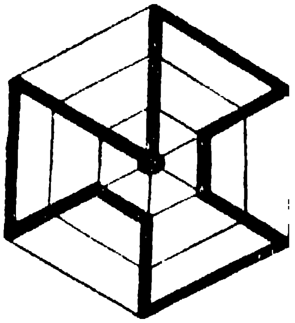
Shaik Mahmoud

MOTHER AND child race: Sita, Tara and Uma took part in a 'mother and child race', along with their children Kalpana, Laxmi and Maina. Each of the women was to pick up any one of the children and run in the race. Maina was the winning child and Laxmi was the heaviest child. Tara with Kalpana weighed as much as Uma with Maina. Each pair taking part in the race weighed the same, but Sita was heavier than Tara. If Sita picked up Kalpana, then Tara would pick up Laxmi. Who was the winning mother?

PROFESSIONS AND hobbies: I invited my friends Ahmed, Bhat and Charlie for a party at my residence. They were selected from among teachers and salesmen. Each was practising painting or photography (not both) as his hobby. Ahmed was not a teacher and Charlie was not a painter. Teachers do not know how to handle the camera (it is a costly hobby, anyway!) and the colleagues do not practise the same hobby. Can you figure out the professions and hobbies of my friends?

V. A. Shenai

(*Solutions next month*)



Solutions to last month's Brain Teasers

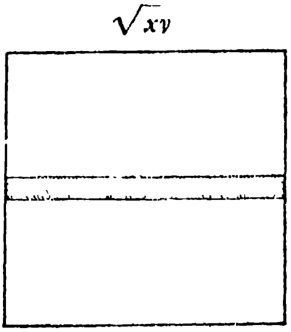
Smart school boys

The shortest route to cover all the junction points is shown by the thick black lines.

Garden paths

The gardens and paths are shown in cols. 1 & 2.

Let the sides of the rectangular garden be x feet and y feet. Hence, the area of the other garden is also xy sq. ft. and its side $\sqrt{xy}$ feet.



The areas of the two paths are:

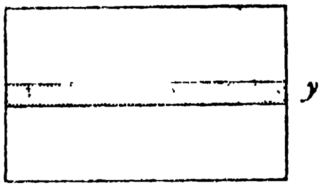
x sq. ft. and $\sqrt{xy}$ sq. ft.

Hence $x \quad \frac{4\sqrt{xy}}{3}$

ie, $x^2 = \frac{16}{9}xy$

ie, $\frac{x}{y} = \frac{16}{9}$

The minimum values of x and y are 16 feet and 9 feet, respectively. In the next set of values (32 feet × 18 feet), one of the sides exceeds 20 feet and hence can be ruled out. The answer is 16 × 9 and 12 × 12.



Shopping puzzle

Let Rs. t, Rs. f and Rs. l be the prices of each tie, face-powder tin and lipstick, respectively.

Now $5t = 7f$ and $11f = 5l$

ie, $55t = 77f = 35l$

so $\frac{t}{f} = \frac{7}{5}$ or $t = 7$ and $f = 5$

and $= \frac{}{11}$ or $t = 7$ and $l = 11$

Thus, $t = 7$, $f = 5$ and $l = 11$ is one set of values.

If x of each of the articles were purchased, $x\ (7 + 5 + 11) + 21$ is the total amount of money we had. I had Rs. 5 × 7 = Rs. 35 and my wife had Rs. 5 × 11 = Rs. 55, making a total of Rs. 90.

Thus $x\ (7 + 5 + 11) + 21 = 90$

or $x = 3$

Therefore, the prices of one tie, one face-powder tin and one lipstick are Rs. 7, Rs. 5 and Rs. 11, respectively, and three of each of these articles were purchased.

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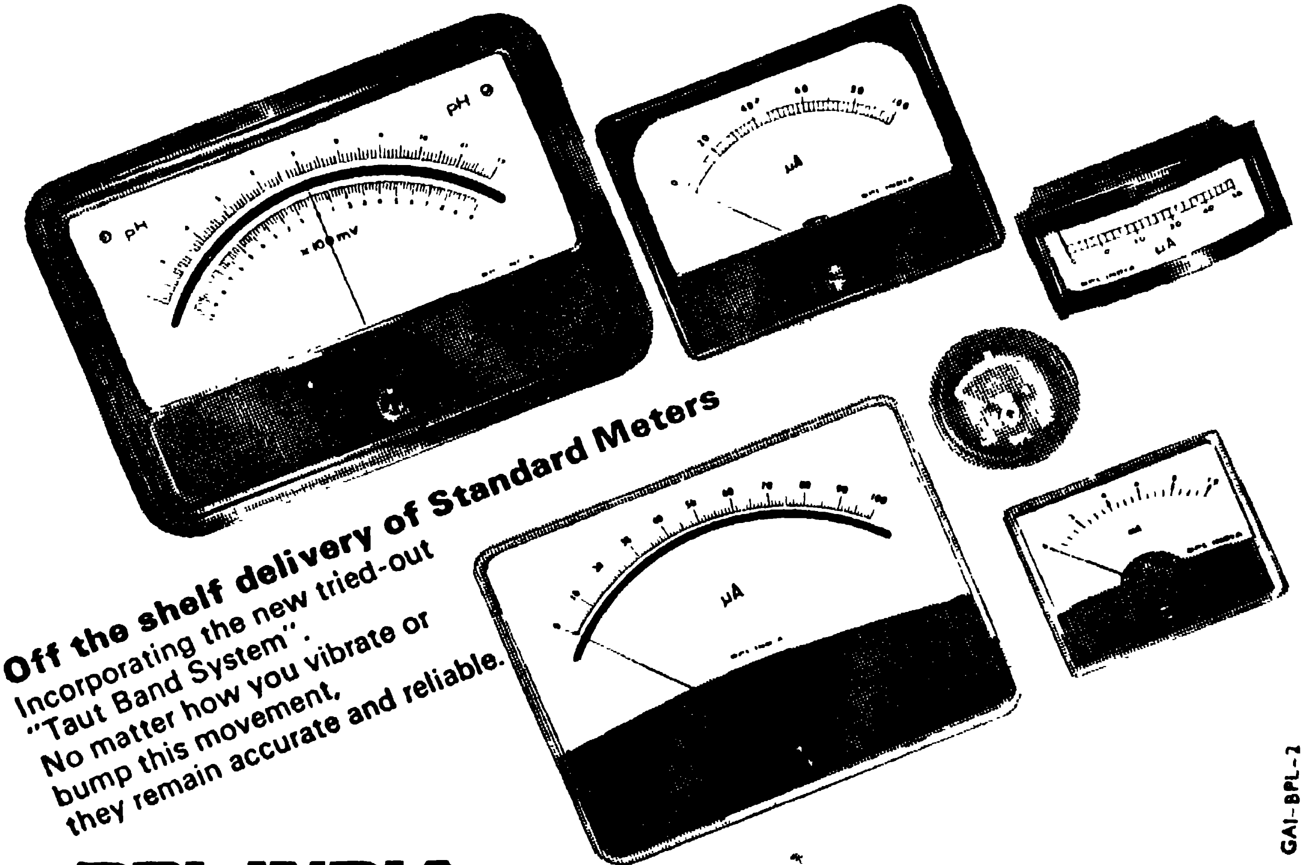

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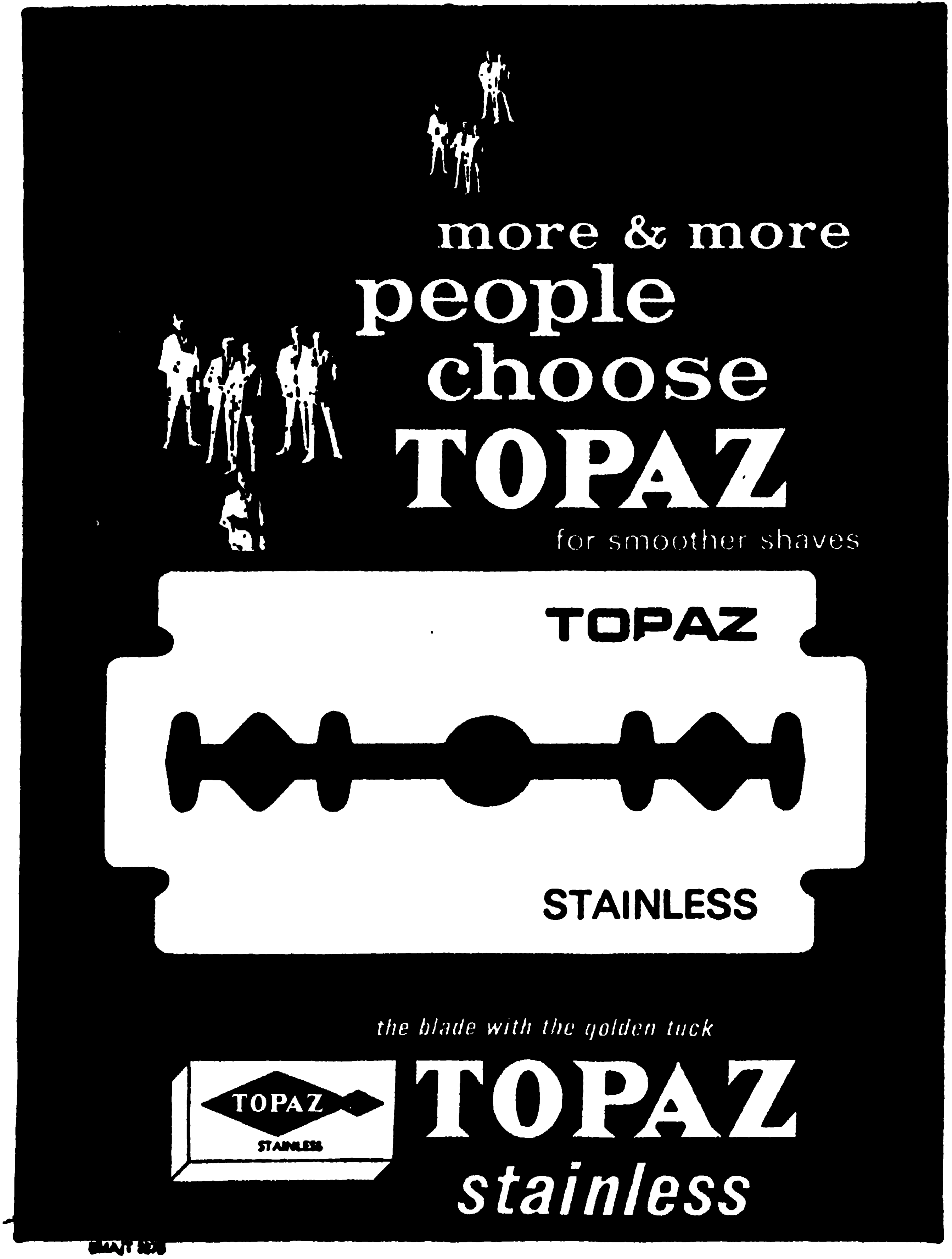

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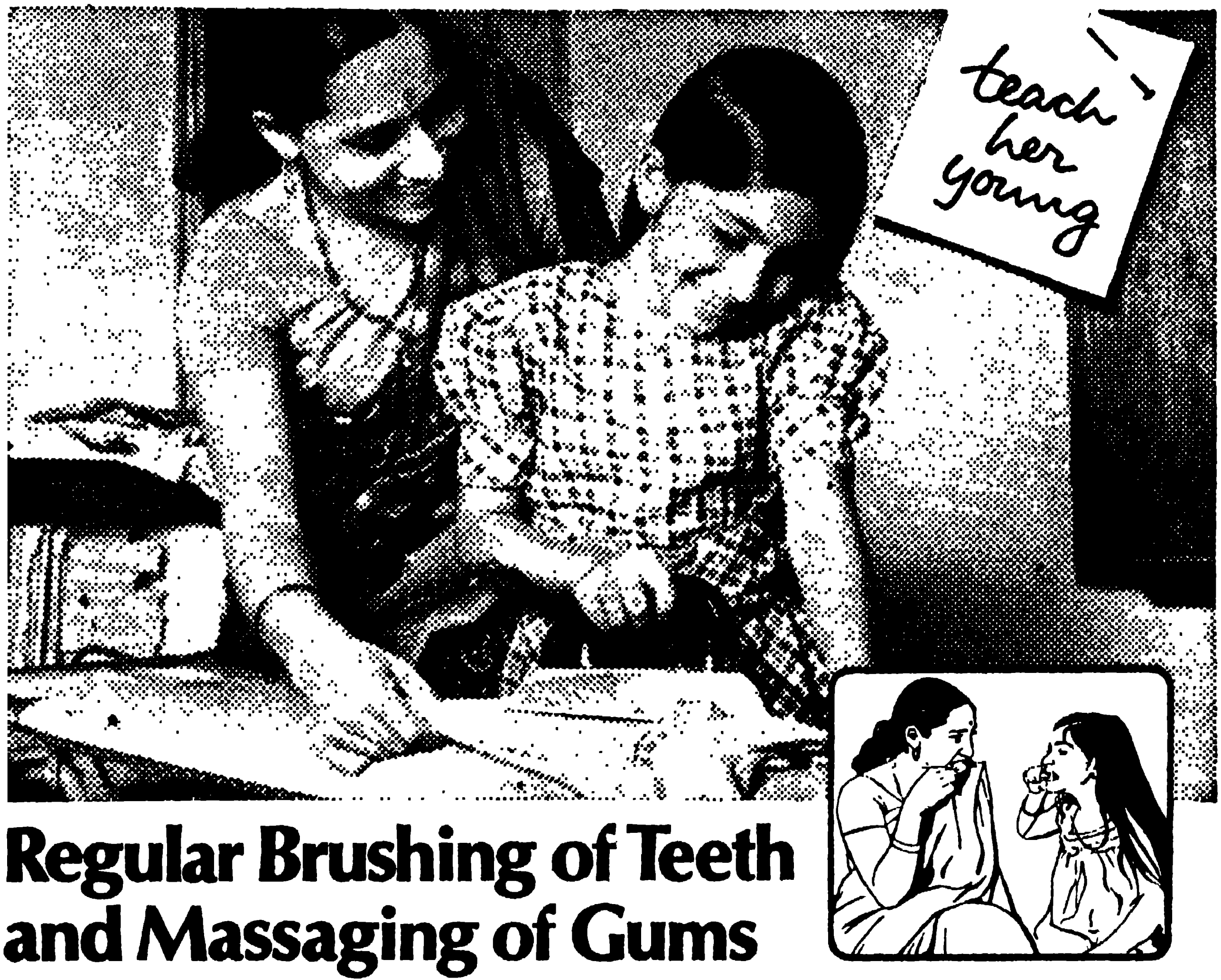

Regular Brushing of Teeth and Massaging of Gums Check Gum Troubles and Tooth Decay.

Dentists say, the best way to keep gums firm and healthy is to massage them regularly. And, the best way to check tooth decay is to brush teeth regularly, night and morning, and after every meal, so that all decay-causing food particles are removed.

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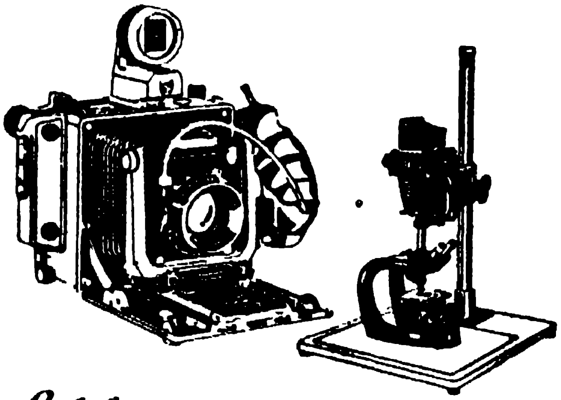

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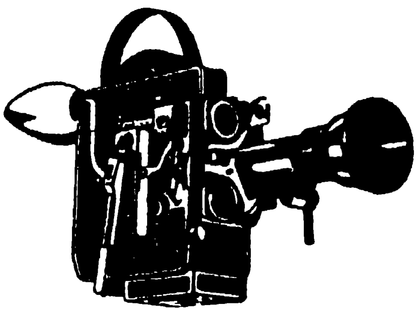

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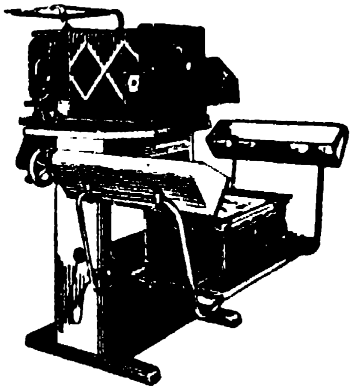

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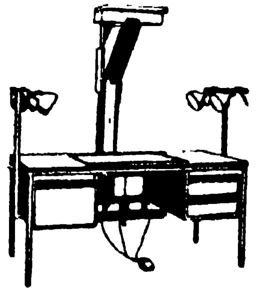

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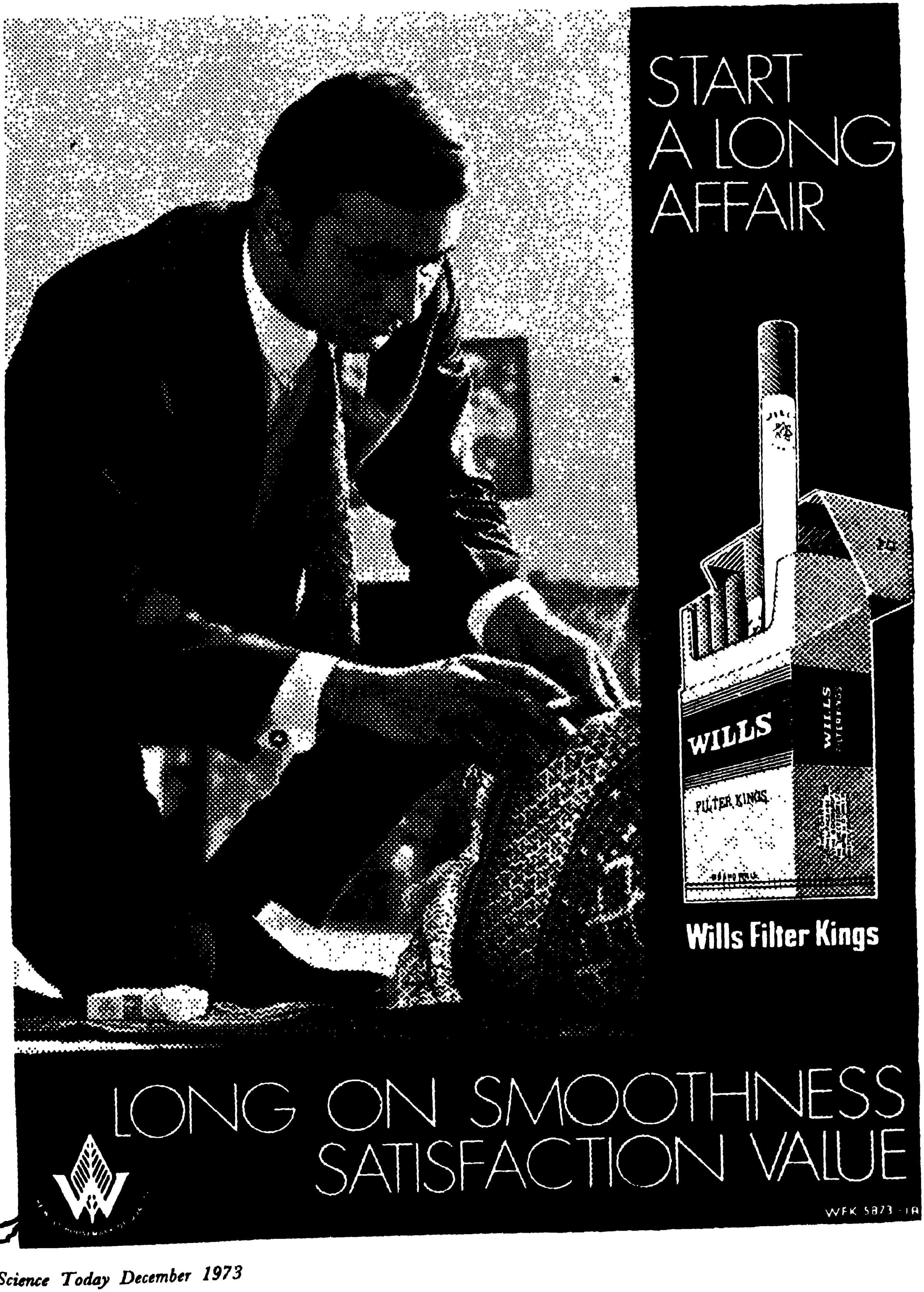
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